MONTHLY NOTICES

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ROYAL ASTRONOMICAL SOCIETY.

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SIR DAVID GILL, K.C.B., F.R.S., PRESIDENT, in the Chair.

Lionel Barton Booth, Aberdour, Pinner Hill Road, Pinner;
Major Gerald Edward Galbraith, R.A., c/o Messrs. Cox & Co., 16 Charing Cross, S.W.;
Thomas King, Government Astronomical Observer for New Zealand, 58 Ellice Street, Wellington, New Zealand;
E. H. V. Melville, P.O. Box 719, Johannesburg, South Africa;
John Rees, Snowdonia, Miskin Street, Cardiff;
Dr. Milan Stefanik, Island of Tahiti, South Pacific (temporary address);
Bruce H. Wade, Chief Inspector, Egyptian Survey Department, Helwân, Egypt; and
Edgar C. Willis, Southwell Lodge, Ipswich Road, Norwich,

were balloted for and duly elected Fellows of the Society.

Dr. Aristarch Bélopolsky, Observatory, Pulkova, Russia;
Hisashi Kimura, International Latitude Station, Mizusawa, Japan; and
Professor W. H. Pickering, Harvard College Observatory, Cambridge, Mass., U.S.A.,

were balloted for and duly elected Associates of the Society.

The following candidates were proposed for election as Fellows

of the Society, the names of the proposers from personal knowledge being appended:—

Frederick William Bateman, Westergate, 20 Corfton Road, Ealing, W. (proposed by T. Davies Sewell);

John Brittain, Lecturer on Astronomy, Local School of Mines, Ballaarat, Victoria, Australia (proposed by James Oddie);

R. Burdon-Martin, Mathematical Master, South African College School, City Mansions, Cape Town, South Africa (proposed by Joseph Lunt);

Rev. David Ross Fotheringham, M.A., 13 Maitland Park Road, Hampstead, N.W. (proposed by J. K. Fotheringham); and

Bernard Guy Harrison, The Grove, Freshford, Somerset (proposed by R. W. B. Moore).

One hundred and twenty-four presents were announced as having been received since the last meeting, including amongst others:—

Lewis Boss, Preliminary General Catalogue of 6188 Stars, prepared at the Dudley Observatory, Albany, presented by the Author; P. H. Cowell and A. C. D. Crommelin, Essay on the return of Halley's Comet, presented by the Authors; F. W. Dyson, Astronomy, a handy manual for students and others, presented by the Author; Bouguer, Traité d'Optique, 1760; and Souciet, Observations mathématiques (etc.), presented by W. Arthur Smith.

Series of photographs of nebulæ, etc., made by G. W. Ritchey with the 60-inch reflector of the Mount Wilson Observatory (enlarged transparencies), presented by Prof. Ritchey; Series of lantern slides of Halley's Comet made by Mr. Knox Shaw at the Khedivial Observatory, Helwân (presented by the Observatory).

On the Systematic Motions of the Bradley Stars. By S. S. Hough, M.A., F.R.S., and J. Halm, Ph.D. (Plates 18, 19.)

In a paper published in the *Monthly Notices*, vol. lxx., No. 1, we drew attention to a new fact relating to the two-drift hypothesis of Kapteyn which was brought to light in a discussion of the systematic motions of the stars by means of their radial velocities. It was pointed out that the data on which that investigation was based revealed anomalies in the distribution of velocities which could be explained on the assumption that the mixture of the two drifts was not uniformly the same over the whole sky. The observed facts could be tolerably accounted for by the hypothesis that in any region of the sky the ratio of the

number of stars in Kapteyn's second drift to the total number of stars can be represented in the form

$$s = s_0 + \epsilon(\alpha x + \beta y + \gamma z),$$

where x, y, z are the direction-cosines referred to the pole and equinox of the point of the heavens under consideration, and α, β, γ the direction-cosines of the point in which the maximum density of the second drift stars occurs.

As a provisional test of the new fact, a rough tentative examination of the transverse motions as furnished by the Bradley-Auwers proper motions was undertaken, with a result apparently confirming our assumption. In a note added to our paper, however, Eddington, by qualitative rather than quantitative reasoning, pointed out that the results derived from our examination should be received with diffidence, as our method could not enable us to separate the two drifts with sufficient accuracy in all parts of the heavens. The validity of this objection is undeniable, and there can only be a difference of opinion as to its presumable quantitative effect on the general character of our result. Our impression at the time, now fully confirmed by the results of this communication, was that this effect could not be great enough to deprive our examination altogether of its value as confirmatory evidence of the result derived from the discussion of radial velocities. But a more critical discussion of the Bradley proper motions relating to this important point had of necessity to be deferred for future consideration, it being considered advisable that the publication of the discussion of the radial velocities should not be delayed on account of a question which had no vital bearing on the direct results of our paper.

The present communication, which contains a critical examination of the Bradley proper motions with reference to the distribution of the stars constituting the two drifts, furnishes probably all the evidence obtainable from this particular source of information. Its results will be found to be emphatic in confirming our previous conclusions, the important bearing of which not only on hitherto recondite problems of stellar dynamics, but also on the eminently practical question of the determination of the constant of precession, will doubtless be recognised.

Method of Investigation.—The statistical method employed by Eddington and Dyson consists in subdividing the sphere into comparatively small areas and counting in each of these areas the number of proper motions contained within the directions θ and $\theta + \Delta\theta$ for all values of θ. In our examination θ represents the position angle of the proper motion in the ordinary sense, *i.e.* the angle between the hour circle passing through the star and the direction of its proper motion. The presence of any prevalent direction of proper motions, such as would be caused by a systematic motion of either the stars or the sun, is indicated by a maximum number of stars occurring in the direction of the drift,

and a minimum number in the opposite direction. The presence of two or more drifts is indicated by two or more corresponding maxima and minima, and the separation of the individual drifts can be effected by an analysis, the key to which is given in the mathematical part of Eddington's paper, *M.N.*, vol. lxvii., No. 1.

Data of Observation.—The selection of the Bradley-Auwers proper motions as the most suitable material for this investigation needs no justification. It must, however, be pointed out that in their original form, in which they were used by Kobold, these proper motions are affected by not inconsiderable errors in the assumed precessional constant and equinox, as well as by systematic errors in Bradley's observations. These errors have been minutely discussed by Newcomb in his paper on the precessional constant (*Astronomical Papers of the American Ephemeris*, vol. viii., part i.), and also independently by Kapteyn (*see Publ. of the Astron. Laboratory at Gröningen*, No. 9, pp. 4–8). The latter publication contains a complete list of the *corrected* Bradley proper motions arranged in galactic zones, and it is from this revised material that the data of the present investigation have been derived. We found it, however, advisable to safeguard even further against the possibility of systematic errors in the revised observations by comparing, at one stage of this investigation, the results obtained from the evidence of all the proper motions with those derived from a material from which proper motions $< 5''$ per century were excluded. It is evident that if the anomalies found in the former material were due, not to some real cause inherent in the systematic motions of the stars themselves, but to systematic errors of the observations, their effect should be greatly diminished by the exclusion of the small proper motions. We may state at once that the results pronounce emphatically against this assumption.

For reasons which will become apparent in the course of this investigation, we have concentrated our examination chiefly on the equatorial belt of stars enclosed within the 30th north and south parallels. But in addition to this zone of stars, special areas round the galactic poles and in the galactic equator were examined in order to obtain confirmatory evidence of the results derived from the equatorial stars. The equatorial belt was subdivided into twelve adjacent areas, each two hrs. wide, whose centres are situated at 1^h, 3^h . . . 23^h R.A. In each of these areas the stars whose proper motions have position-angles between $0°$–$15°$, $15°$–$30°$ . . . $345°$–$0°$ were counted. The numbers are given in Table I. arranged in order of θ, and this table also contains the corresponding data for the galactic area comprised between galact. long. $60°$ and $120°$ and galact. lat. $\pm 30°$.

Table I.

θ	h h 0–2	h h 2–4	h h 4–6	h h 6–8	h h 8–10	h h 10–12	h h 12–14	h h 14–16	h h 16–18	h h 18–20	h h 20–22	h h 22–0	Galaxy, Long. 90°.	θ
						Equator.								
° ° 0–15	2	0	5	4	1	1	1	1	0	5	1	2	9	° ° 0–15
15–30	2	2	2	3	1	1	1	0	4	4	5	0	7	15–30
30–45	6	6	5	3	0	1	0	0	2	6	3	1	6	30–45
45–60	5	3	3	2	1	0	1	1	2	10	9	4	10	45–60
60–75	4	3	4	6	4	1	0	3	2	9	7	10	9	60–75
75–90	14	8	7	3	3	0	1	1	4	5	16	22	26	75–90
90–105	14	14	5	5	2	6	1	4	5	11	20	14	34	90–105
105–120	18	14	11	4	2	8	5	4	3	9	15	15	34	105–120
120–135	5	15	15	4	4	6	5	5	4	13	12	15	27	120–135
135–150	10	11	20	9	5	1	5	7	4	8	13	13	16	135–150
150–165	6	11	18	6	4	5	5	4	6	8	8	6	15	150–165
165–180	4	7	15	7	3	2	6	6	5	13	10	7	10	165–180
180–195	3	8	12	10	11	6	3	8	10	15	8	5	7	180–195
195–210	9	12	11	15	9	4	5	13	13	13	13	6	9	195–210
210–225	10	8	10	14	13	7	12	17	12	10	9	13	10	210–225
225–240	9	8	9	8	16	8	16	17	7	9	7	7	12	225–240
240–255	10	7	4	9	20	12	19	17	9	4	7	10	13	240–255
255–270	5	6	4	9	14	21	18	12	7	5	5	5	10	255–270
270–285	1	2	1	9	12	25	14	9	9	3	3	4	9	270–285
285–300	5	2	1	9	8	9	5	6	2	3	3	4	9	285–300
300–315	1	1	6	8	7	5	1	1	4	1	2	1	7	300–315
315–330	0	1	4	5	5	4	3	2	5	4	2	0	3	315–330
330–345	1	2	3	5	0	3	1	3	1	2	1	4	2	330–345
345–0	1	1	2	7	2	2	0	0	2	7	1	5	7	345–0

Analytical Examination of the observed Data.—The mathematical theory on which this examination is based has been fully and most clearly expounded in Eddington's important paper already referred to. The practical application of his formula is simple enough to require no further explanation, and we may therefore confine ourselves to quoting the results in a form identical with that of Table VIII. on p. 50 of his paper. The numerical data are supplied by Table I. of the present communication. It must be stated, however, that it was found necessary, in order to reduce the effects of accidental discrepancies on the determination of the constants involved, to combine two neighbouring areas into one, *e.g.* 23^h and 1^h, 1^h and 3^h, etc. We obtain thus areas whose centres lie at 0^h, 2^h, etc. R.A. and on the equator. The areas 6^h and 18^h had to be omitted on account of their proximity to the apices of the two drifts, the separation of the two drifts being

thereby rendered extremely difficult. A further smoothing was effected in the results by combining each two neighbouring numbers. Thus the number quoted against $\theta = 0°$ is the sum of stars contained between $\theta = -15°$ and $\theta = +15°$.

The result of the analysis which was effected by a method of trial and error is shown in Table II.

TABLE II.

(a) *Equatorial Areas.*

		Drift I.	Drift II.
Area 0^h	Number of Stars	188	122
	hV	1·20	1·05
	θ_0 (direction of drift)	102°	230°
Area 2^h	Number of Stars	187	109
	hV	1·05	1·05
	θ_0	110°	225°
Area 4^h	Number of Stars	195	138
	hV	0·70	0·55
	θ_0	127°	206°
Area 8^h	Number of Stars	199	97
	hV	0·75	0·35
	θ_0	115°	202°
Area 10^h	Number of Stars	218	70
	hV	1·05	0·65
	θ_0	103°	225°
Area 12^h	Number of Stars	210	58
	hV	1·20	1·00
	θ_0	101°	230°
Area 14^h	Number of Stars	203	59
	hV	1·10	1·00
	θ_0	115°	230°
Area 16^h	Number of Stars	195	72
	hV	0·95	0·50
	θ_0	127°	220°
Area 20^h	Number of Stars	200	158
	hV	0·80	0·80
	θ_0	102°	202°
Area 22^h	Number of Stars	198	156
	hV	1·10	0·70
	θ_0	103°	217°

TABLE II.—*continued.*

(a) *Equatorial Areas.*

	Total Number of Stars.			Total Number of Stars.	
	Obs.	Comp.		Obs.	Comp.
Area 0^h	316	310	Area 12^h	266	268
2	298	296	14	269	262
4	330	333	16	272	267
8	308	296	20	352	358
10	285	288	22	351	354

(b) *Galactic Area* (*Galact. Long.* 90°, *Lat.* 0°).

	Drift I.	Drift II.
Number of Stars.	165	134
hV	1·30	0·50
θ_0	107°	252°

In fig. 1 (Plate 18) we show diagrammatically for the 10 equatorial areas the curves representing the star numbers of Table I. as functions of the position-angle θ, counted from north over east in the areas 20^h to 4^h, and from north over west in the areas 8^h to 16^h. In addition we exhibit the corresponding curves for the two polar caps included within 60° galactic latitude. In all cases the broken line represents the actually observed curve, while the smoothed line shows the theoretical curve computed from the data supplied in Table II.

The differences between the two curves are of the same average magnitude as those found by Eddington in his discussion of the Groombridge stars, and may on the whole be taken as purely accidental.

Determination of the Apices of the two Drifts.—The existence of two distinct maxima in the curves represented by the numbers of Table I. (see also fig. 1) points at once to the presence of two drifts. To establish, however, that these maxima are really due to drift motions, it is necessary to show that the great circles represented by the drift directions θ_0 in each curve intersect in two opposite points, the apex and anti-apex of the drift. It is easily seen, from the spherical triangle between the pole of the heavens, the apex of the drift, and the centre of the area, that the required condition is satisfied, if

$$\tan\theta_0 = [\tan\theta_0 \tan\delta \cos\alpha - \sec\delta \sin\alpha] \cot D \cos A + [\tan\theta_0 \tan\delta \sin\alpha + \sec\delta \cos\alpha] \cot D \sin A,$$

where θ_0 is the position-angle of the drift direction given in Table II.; α, δ are the R.A. and Decl. of the centre of the area, and A and D those of the apex. Since the left-hand term and the bracketed terms of the above equation are known quantities, we derive for each area an equation of condition for the two

unknowns $x = \cot D \cos A$; $y = \cot D \sin A$, from which the most probable values of A and D may be determined. Computing with these the values of θ_0', which fulfil the apex condition rigorously, and also the arc a between the centre of each area and the apex, we find easily the minimum distance Δ, at which the observed great circle of drift motion passes the apex, from the equation

$$\Delta = (\theta_0 - \theta_0') \sin a.$$

The order of magnitude of Δ affords a measure of the accuracy with which the observations satisfy the condition that the observed motions are real drift-motions.

The assignment of proper weights to the equations of condition is a somewhat obscure problem. Doubtless the uncertainty of the observed angle θ_0 increases rapidly in the vicinity of the apex. Thus, since the apices of both drifts lie approximately in 6^h and 18^h R.A., the determination of θ_0 is much more certain for the 0^h area than for the 4^h and 8^h area. It was considered sufficient to assign our weights at least in the proper direction, by assuming the precision of the determination of $\tan \theta_0$ to be a constant for all the areas. This would imply that the probable error of θ_0 is proportional to $\cos^2 \theta_0$; and inasmuch as $\cos \theta_0$ assumes its maximum value (unity) when the R.A. of the area coincides with that of the apex, we see that our assumption fulfils, at least qualitatively, the required conditions of weights.

We have thus for the determination of x and y the following equations:—

Area.		*Drift I.* Observed θ_0.				Δ	*Drift II.* Observed θ_0.				Δ
h	h	°				°	°				°
0,	12	102	$-4{\cdot}70$	$-0{\cdot}00x$	$+1{\cdot}00y$	1	230	$+1{\cdot}19$	$-0{\cdot}00x$	$+1{\cdot}00y$	1
2,	14	112	$-2{\cdot}47$	$-0{\cdot}50x$	$+0{\cdot}87y$	5	227	$+1{\cdot}07$	$-0{\cdot}50x$	$+0{\cdot}87y$	0
4,	16	127	$-1{\cdot}33$	$-0{\cdot}87x$	$+0{\cdot}50y$	5	213	$+0{\cdot}65$	$-0{\cdot}87x$	$+0{\cdot}50y$	1
8,	20	251	$+2{\cdot}90$	$-0{\cdot}87x$	$-0{\cdot}50y$	2	158	$-0{\cdot}40$	$-0{\cdot}87x$	$-0{\cdot}50y$	3
10,	22	257	$+4{\cdot}33$	$-0{\cdot}50x$	$-0{\cdot}87y$	1	139	$-0{\cdot}87$	$-0{\cdot}50x$	$-0{\cdot}87y$	2
Galactic: $\lambda = 90°$, $b = 0°$		107	$-6{\cdot}77$	$-6{\cdot}71x$	$+1{\cdot}05y$	0	252	$+3{\cdot}07$	$+5{\cdot}55x$	$+3{\cdot}22y$	0

The solution of these equations leads to the following co-ordinates of the apices:—

$$A = 87°{\cdot}0 \pm 1°{\cdot}7 \qquad A = 275°{\cdot}8 \pm 0°{\cdot}8$$
$$D = -13°{\cdot}0 \pm 1°{\cdot}0 \qquad D = -41°{\cdot}0 \pm 0°{\cdot}6$$

and the smallness of the residuals Δ establishes the proof that the systematic motions revealed by the numbers in Table I. are indeed to be considered as the apparent motions of two drifts.

Assuming that h is the same for both drifts, we find that the

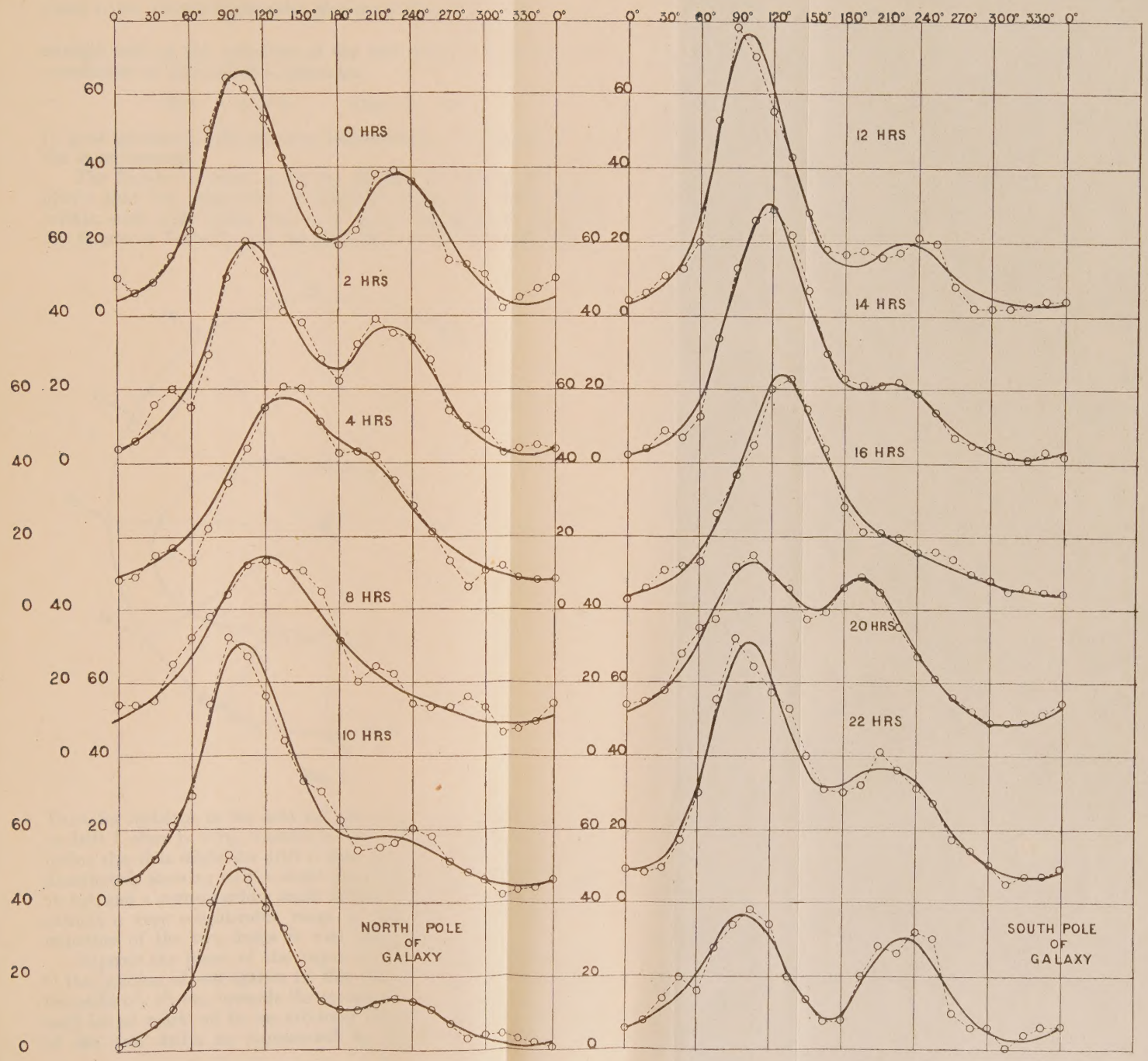

0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300° 330° 0°
0 HRS
2 HRS
4 HRS
8 HRS
10 HRS
12 HRS
14 HRS
16 HRS
20 HRS
22 HRS
NORTH POLE OF GALAXY
SOUTH POLE OF GALAXY

Fig. 1.

average ratio of the velocities of the two drifts is 3 : 2, and the coordinates of their relative vertex are

$$\text{R.A.} = 270^\circ{\cdot}0 \qquad \text{Decl.} = -8^\circ{\cdot}2,$$

in good agreement with previous determinations of this point from the same material.

The Number of Stars in the two Drifts.—It will be seen at a glance that the proportion of mixture of the two drifts varies within such wide limits that it is quite impossible to reconcile the figures of Table II. with the assumption of uniform distribution.

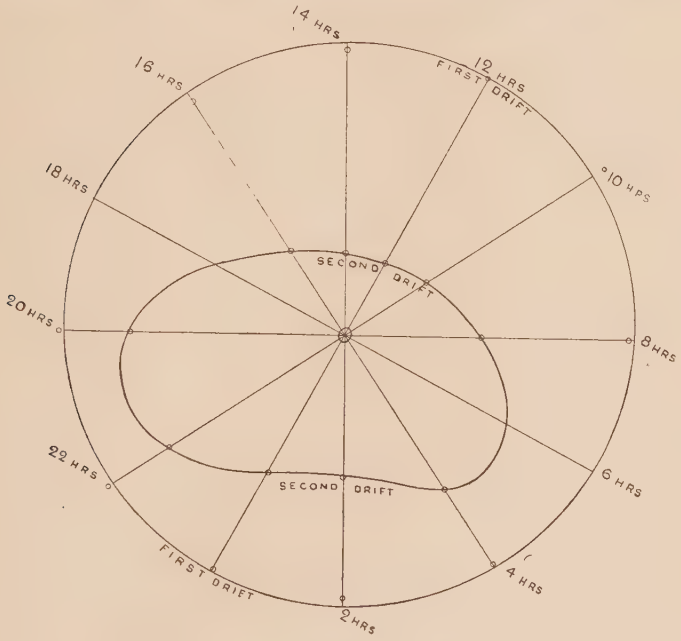


Fig. 2.

Thus, for instance, in the area 22^h the proportion of drift II. stars to drift I. stars is 0·79, whereas in area 12^h it is only 0·28. We notice also that while the drift I. stars appear to be fairly uniformly distributed, showing only a slight preponderance over their average at 12^h, and a corresponding small deficiency at 0^h, the drift II. stars exhibit a very considerable range of variation. The actual distribution of the two drifts is well illustrated in fig. 2.

Suppose the plane of the paper to represent the equator and O the position of our system in this plane. From O let us draw the radii 0^h, 2^h, etc. towards the centres of our areas, and on these radii let us mark off in an arbitrary linear measure the densities of the two drifts as represented by the numbers of stars in

Table II. Drawing the smoothed curves through the points thus marked we then obtain figures in which the radii vectores from O to any point of their circumference denote the density of the drift stars in that particular direction.

Now, with regard to the stars of drift I., it will be readily seen that the conditions are well satisfied by a circle whose centre is slightly displaced towards 12^h.

Quite different, however, is the distribution of the stars of drift II. Instead of a circle, the density curve is represented by a highly elongated ellipse (or rather a bean-shaped figure), whose principal elongation is in the direction 7^h–19^h.

The significant feature is that the direction of greatest density of the second drift agrees almost exactly with that diameter which passes through the galaxy, and, vice versa, *that the direction of minimum condensation falls in that diameter which meets the sphere in the closest proximity to the galactic poles.*

The correspondence between the distribution of stars in the second drift and the Milky Way is further strengthened by the fact, quite apparent from the diagram, that the solar system is not situated in the centre of the ellipse, but is appreciably displaced towards twelve hrs., *i.e.* in a direction very nearly corresponding with that of the northern pole of the galaxy. It is well known, on the other hand, that the ring of the galaxy is not a great circle in the heavens, and that exactly such a displacement of our system with regard to its central plane as is indicated by the distribution of the second drift stars would be required to account for its eccentric position.

The Velocities of the Drifts.—A study of the numerical data exhibited in Table I. reveals the interesting fact that the quantities hV undergo appreciable changes when proceeding from the poles to the equator of the galaxy. If a denotes the angular distance of the centre of the selected area from the apex, then, according to the two-drift theory in its original form, hV cosec a should be a constant. As the two apices lie very close to the hour circle $90°$–$270°$, we may combine the material into three groups comprising the areas 0^h and 12^h; 2^h, 10^h, 14^h, 22^h; and 4^h, 8^h, 16^h, 20^h respectively, and may assume the same value of a for the constituents within each group. There is a wide range in the observed values of hV, especially in the last group, doubtless due to the proximity of the apices, which renders the analysis difficult.

We find—

Group.	hV cosec a. Drift I.	hV cosec a. Drift II.	Ratio Drift I. : Drift II.
0^h, 12^h	1·20	1·03	1·17
2^h, 10^h, 14^h, 22^h	1·24	0·92	1·35
4^h, 8^h, 16^h, 20^h	1·48	0·73	2·00
Galactic Area	1·30	0·63	2·06

Comparing now the results of the last group, which are

representative of the conditions prevailing in the plane of the galaxy with those of the group 0^h–12^h, which is in close proximity to the galactic poles, we see that the numerical values for hV cosec a agree fairly well in the case of the first drift, but a considerable diminution from the galactic pole to equator, which appears to be borne out by the intermediate groups, is noticed in the second drift.

It may be remarked, by the way, that a represents the angular distance between the centre of the area and the apex of the drift, and it has been supposed that cosec a represents the average value of this quantity for the whole area. This assumption is incorrect when the dimensions of the area are great, and especially in the neighbourhood of the apex. To estimate its effect we have computed the average values of cosec a for the three equatorial groups 0^h, 2^h, and 4^h, and the resulting values of hV cosec a applicable to the first drift. We find respectively 1·32, 1·28, 1·37. Hence we may conclude that there is no appreciable change in the quantities from the galactic poles to the galactic equator. As h is inversely proportional to the average *motus peculiaris* of the drift, and V cosec a represents the speed of the drift, we may infer that neither of the two motions is a function of the positions of the stars in the drift. The observed conditions would be completely satisfied by the assumption that drift I. represents a chaotic assemblage of stars endowed with no other than chance motions, *i.e.* its centre of gravity being at rest, in which our Sun is moving with a uniform speed.

The phenomena connected with the second drift, however, do not admit of a similar explanation. The fact that the quantity hV cosec a is considerably diminished when we approach the galaxy is irreconcilable with the assumption of purely chaotic conditions of motion. On the contrary, the observations offer strong evidence of a structural design, not only in regard to the arrangement of the masses, but also in regard to the motions. We cannot possibly avoid the conclusion that the motions of the stars constituting the so-called second drift are not reconcilable with the assumption of a drift pure and simple, but that this assemblage of stars is undergoing a systematic geometrical deformation, the motions due to which depend on their position in the drift. For the first time we are brought face to face with a dynamical differentiation between the two drifts, which doubtless is of great importance for the general aspect of the problem of star motion. Our results in this respect will be materially strengthened by the investigation contained in the next paragraph.

It is interesting to note that in the galaxy the Bradley stars approach those conditions, both with regard to the relative densities of the two drifts and the ratio of their apparent velocities, which Eddington found in his examination of the Groombridge stars, the majority of which are confined to low galactic latitudes.

Comparison between the results obtained from great and small proper motions.—We wish here to point out some facts which seem

to be in strong support of the conclusions reached in the preceding paragraph. It is sufficient for our purpose to examine more closely the conditions in the 0^h area when the limiting conditions of included proper motions are varied. This area has been selected on account of its great distance from both apices, and the consequently large amplitude of both drift motions, as well as their wide separation from one another. The available stars were subdivided into two groups, one of these containing stars whose proper motions on a great circle are *less* than 7″ per century, and the other containing the stars whose proper motions are *greater* than 12″ per century. Within these groups the stars were counted in the ordinary way with reference to the position-angle θ of their proper motions, the result of this counting, expressed in percentages of the total number, being represented in graphical form in the first and second curves of fig. 3 (Plate 19). As a third curve we reproduce the results obtained by Dyson for the same area from an examination of proper motions exceeding 20″ per century. We see at a glance that the selection with regard to magnitude of proper motions has no sensible effect on the direction of the motion of the first drift ($\theta_0 = 100°$). This is exactly what should be expected if our system were moving in a chaos. As regards the second drift, whose maximum appears in the right-hand half of the curves, evidently the direction of the drift motion depends to a large extent on the average magnitude of the proper motions, and therefore on the distances of the stars from us. In order to explain the considerable displacements in the directions towards the apparent apex, so clearly shown in the curves, it is necessary to assume an inherent systematic motion in the drift itself, whose magnitude and direction depend on the magnitude of the proper motions, and therefore presumably on the parallax. The general conclusion of the preceding paragraph is thus well supported.

Examination of opposite Areas.—The inequality of distribution of the two drifts, which has been so clearly revealed in the preceding analysis of the Bradley proper motions, may also be demonstrated without the aid of Eddington's analysis by a purely statistical comparison of exactly opposite areas, such as 0^h and 12^h, 2^h and 14^h, etc. It can be easily shown by a simple geometrical consideration that whatever may be the number and positions of the apices of the individual drifts, the curves for two opposite areas represented by the numbers in Table I. should be exactly similar, provided that the drifts in both areas are mixed in exactly the same proportions; and if the numbers are expressed in percentages of the total number of stars contained in the area, the curves should be identical, apart from purely accidental differences. A want of symmetry in the arrangement of the drifts, such as was indicated in the investigation of radial velocities of our former paper, should therefore become at once detectable from the character of the difference between the numbers referring to the corresponding values θ and $360° - \theta$ in opposite areas. If the drifts are evenly mixed over the whole sphere, the differences

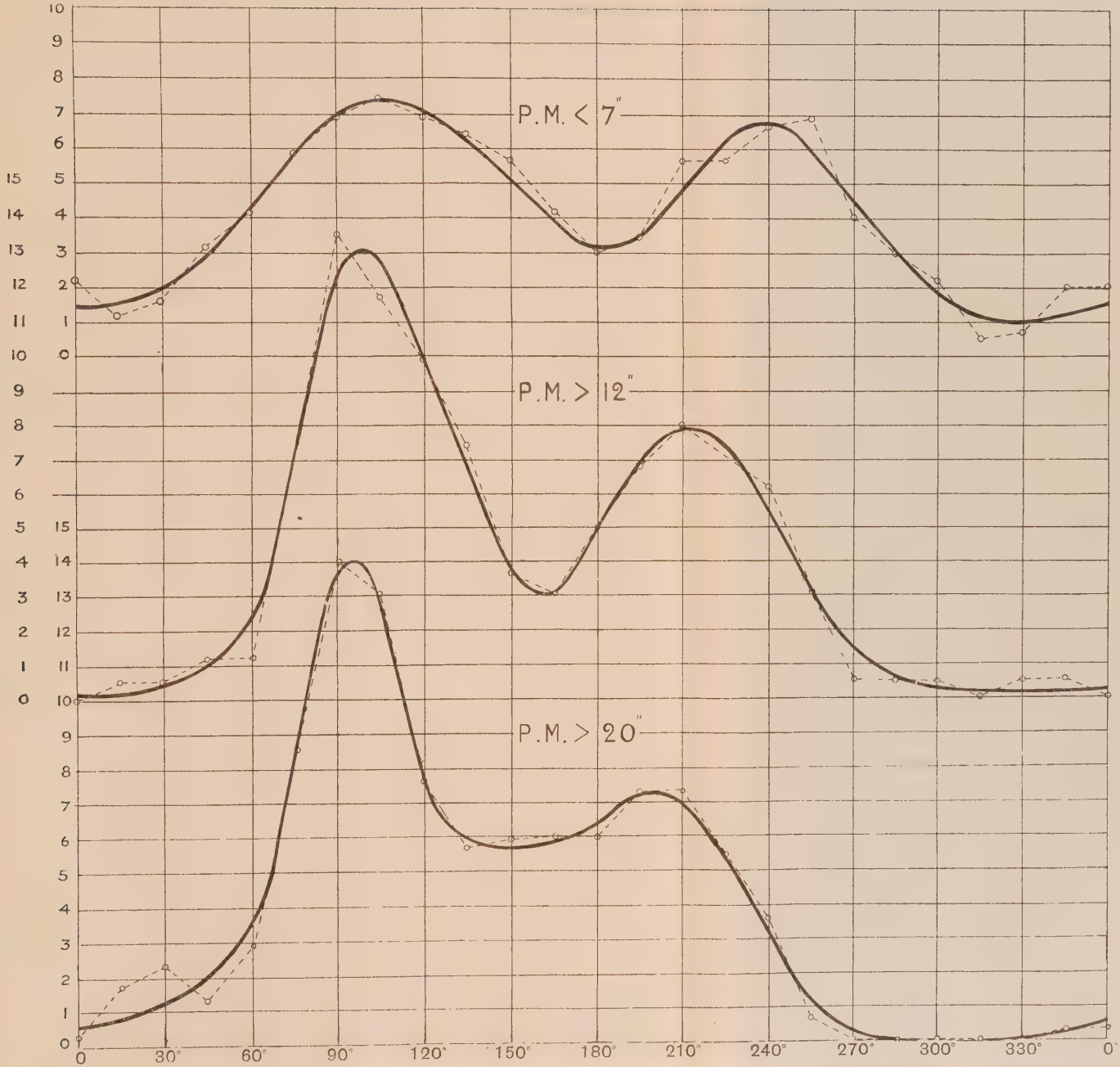


Fig. 3.

TABLE IIIA.

Opposite Equatorial Areas. All Proper Motions.

θ	1^h %	13^h %	13^h-1^h Diff.	3^h %	15^h %	15^h-3^h Diff.	5^h %	17^h %	17^h-5^h Diff.	7^h %	19^h %	19^h-7^h Diff.	9^h %	21^h %	21^h-9^h Diff.	11^h %	23^h %	23^h-11^h Diff.	θ
0°	1·0	0·5	−0·5	0·7	0·6	−0·1	1·8	1·1	−0·7	3·1	2·9	−0·2	0·8	0·9	+0·1	1·2	1·4	+0·2	0°
15	1·7	0·8	−0·9	1·2	1·1	−0·1	2·0	1·4	−0·6	3·4	3·0	−0·4	1·2	1·5	+0·3	1·8	1·0	−0·8	15
30	2·6	1·2	−1·4	2·1	1·3	−0·8	2·1	2·3	+0·2	3·6	3·3	−0·3	2·2	2·4	+0·2	2·5	0·8	−1·7	30
45	3·2	1·8	−1·4	2·5	1·8	−0·7	2·1	2·7	+0·6	4·1	4·3	+0·2	3·6	3·3	−0·3	3·6	1·9	−1·7	45
60	4·4	3·8	−0·6	2·9	3·0	+0·1	2·5	3·3	+0·8	4·9	4·6	−0·3	5·3	4·7	−0·6	6·8	4·9	−1·9	60
75	6·3	7·4	+1·1	4·3	5·1	+0·8	2·9	4·2	+1·3	5·4	4·6	−0·8	6·9	6·9	0·0	11·3	7·9	−3·4	75
90	9·0	11·5	+2·5	6·7	7·7	+1·0	3·7	5·4	+1·7	5·5	4·8	−0·7	9·1	8·7	−0·4	13·8	9·4	−4·4	90
105	9·5	13·6	+4·1	8·7	9·9	+1·2	5·1	7·3	+2·2	5·4	5·5	+0·1	10·9	9·1	−1·8	12·1	9·2	−2·9	105
120	8·0	13·0	+5·0	9·1	11·5	+2·4	7·3	9·0	+1·7	5·8	5·9	+0·1	11·2	8·1	−3·1	8·4	8·4	0·0	120
135	6·2	10·4	+4·2	8·4	11·6	+3·2	9·4	10·1	+0·7	6·9	5·6	−1·3	9·9	6·8	−3·1	5·5	7·4	+1·9	135
150	4·7	6·9	+2·2	7·2	10·1	+2·9	10·4	9·7	−0·7	7·7	5·5	−2·2	8·1	6·0	−2·1	4·3	5·8	+1·5	150
165	3·8	4·4	+0·6	6·0	7·7	+1·7	9·2	8·0	−1·2	7·2	6·1	−1·1	6·4	5·3	−1·1	3·5	4·2	+0·7	165
180	3·3	3·6	+0·3	5·8	5·3	−0·5	7·8	6 2	−1·6	5·6	7·3	+1·7	4·6	5·3	+0·7	3·0	3·5	+0·5	180
195	4·4	3·9	−0·5	6·0	4·1	−1·9	6·7	4·6	−2·1	4·6	7·5	+2·9	3·4	5·7	+2·3	2·5	5·0	+2·5	195
210	5·8	4·0	−1·8	6·1	3·9	−2·2	5·9	3·7	−2·2	4·2	6·6	+2·4	2·8	5·5	+2·7	2·4	4·8	+2·4	210
225	6·6	3·9	−2·7	5·6	3·8	−1·8	5·0	3·2	−1·8	3·7	5·2	+1·5	2·7	4·9	+2·2	3·2	5·4	+2·2	225
240	6·1	3·4	−2·7	4·8	3·4	−1·4	3·8	2·9	−0·9	3·0	3·9	+0·9	2·2	3·9	+1·7	4·2	5·0	+0·8	240
255	4 6	2·3	−2·3	4·0	2·6	−1·4	2·5	3·0	+0·5	2·5	2·8	+0·3	1·7	3·2	+1·5	4·1	4·0	−0·1	255
270	3·1	1·2	−1·9	2·7	2·0	−0·7	1·4	2·9	+1·5	2·6	2·2	−0·4	1·8	2·4	+0·6	2·5	3·1	+0·6	270
285	2·1	0·5	−1·6	1·6	1·5	−0·1	1·4	2·4	+1·0	2·5	1·7	−0·8	1·9	1·8	−0·1	1·0	2·1	+1·1	285
300	1·5	0·4	−1·1	1·0	1·1	+0·1	1·9	1·8	−0·1	2·2	1·5	−0·7	1·5	1·4	−0·1	0·4	1·4	+1·0	300
315	0·9	0·4	−0·5	0·9	0·6	−0·3	2·3	1·8	−0·5	1·9	1·5	−0·4	0·8	1·1	+0·3	0·5	1·0	+0·5	315
330	0·5	0·5	0·0	0·9	0·3	−0·6	2·0	1·8	−0·2	1·8	1·9	+0·1	0·5	0·8	+0·3	0·6	1·0	+0·4	330
345	0·7	0·5	−0·2	0·8	0·3	−0·5	1·7	1·5	−0·2	2·4	2·5	+0·1	0·7	0·7	0·0	0·8	1·5	+0·7	345

TABLE IIIB.

Opposite Equatorial Areas. Kobold's selected Proper Motions.

θ	1^h %	13^h %	13^h–1^h Diff.	3^h %	15^h %	15^h–3^h Diff.	5^h %	17^h %	17^h–5^h Diff.	7^h %	19^h %	19^h–7^h Diff.	9^h %	21^h %	21^h–9^h Diff.	11^h %	23^h %	23^h–11^h Diff.	θ
0°	0·4	0·5	+ 0·1	0·7	0·5	– 0·2	1·8	0·6	– 0·8	1·3	2·0	+ 0·7	0·2	0·3	+ 0·1	0·9	0·9	0·0	0°
15	0·6	1·0	+ 0·4	0·7	0·7	0·0	2·0	0·9	– 1·1	0·9	2·3	+ 1·4	0·2	1·3	+ 1·1	0·9	0·6	– 0·3	15
30	1·0	1·4	+ 0·4	0·9	0·8	– 0·1	2·0	1·5	– 0·5	0·6	2·6	+ 2·0	0·9	2·3	+ 1·4	1·5	0·8	– 0·7	30
45	1·2	2·3	+ 1·1	0·9	1·6	+ 0·7	2·0	2·7	+ 0·7	1·9	3·8	+ 1·9	1·5	3·0	+ 1·5	2·9	1·7	– 1·2	45
60	2·7	5·2	+ 2·5	1·3	3·9	+ 2·6	3·0	3·9	+ 0·9	4·6	4·3	– 0·3	4·0	3·8	– 0·2	7·7	4·5	– 3·2	60
75	5·6	10·8	+ 5·2	3·3	7·1	+ 3·8	4·3	5·4	+ 1·1	6·8	3·4	– 3·4	9·1	6·3	– 2·8	12·8	8·1	– 4·7	75
90	9·4	16·3	+ 6·9	6·2	11·2	+ 5·0	5·0	6·3	+ 1·3	7·7	2·3	– 5·4	15·1	8·4	– 6·7	17·1	10·5	– 6·6	90
105	10·8	18·2	+ 7·4	8·9	13·9	+ 5·0	4·0	8·4	+ 4·4	7·7	3·4	– 4·3	18·0	7·9	– 10·1	16·0	9·9	– 6·1	105
120	9·3	15·3	+ 6·0	9·3	13·6	+ 4·3	3·3	10·1	+ 6·8	7·4	6·1	– 1·3	15·9	6·6	– 9·3	12·0	7·5	– 4·5	120
135	6·2	10·3	+ 4·1	8·0	11·2	+ 3·2	5·0	11·3	+ 6·3	9·3	6·3	– 3·0	11·9	5·6	– 6·3	6·9	5·4	– 1·5	135
150	3·9	5·4	+ 1·5	6·0	7·6	+ 1·6	8·3	10·7	+ 2·4	10·8	6·1	– 4·7	7·6	6·1	– 1·5	3·5	3·6	+ 0·1	150
165	3·5	3·1	– 0·4	4·9	5·4	+ 0·5	10·9	9·5	– 1·4	10·8	7·5	– 3·3	5·1	6·3	+ 1·2	2·2	2·3	+ 0·1	165
180	3·7	2·4	– 1·3	5·8	3·4	– 2·4	10·6	8·1	– 2·5	8·0	10·1	+ 2·1	3·2	6·8	+ 3·6	2·0	1·7	– 0·3	180
195	4·6	2·3	– 2·3	7·3	2·6	– 4·7	9·3	6·0	– 3·3	6·2	9·8	+ 3·6	2·3	7·6	+ 5·3	2·0	3·8	+ 1·8	195
210	5·8	1·7	– 4·1	8·2	3·1	– 5·1	7·9	4·2	– 3·7	5·6	7·5	+ 1·9	1·5	7·3	+ 5·8	1·5	6·2	+ 4·7	210
225	7·3	1·1	– 6·2	7·3	3·4	– 3·9	7·0	3·3	– 3·7	4·6	5·5	+ 0·9	0·8	6·3	+ 5·5	1·8	8·2	+ 6·4	225
240	7·9	0·9	– 7·0	5·8	2·9	– 2·9	5·3	2·4	– 2·9	2·5	4·3	+ 1·8	0·5	5·1	+ 4·6	2·0	8·6	+ 6·6	240
255	6·2	0·7	– 5·5	4·4	1·9	– 2·5	3·0	1·5	– 1·5	0·6	2·9	+ 2·3	0·5	3·3	+ 2·8	2·2	6·8	+ 4·6	255
270	4·1	0·5	– 3·6	3·1	1·5	– 1·6	1·3	0·6	– 0·7	0·0	1·7	+ 1·7	0·6	2·3	+ 1·7	1·1	4·3	+ 3·2	270
285	2·3	0·2	– 2·1	1·8	1·3	– 0·5	0·7	0·6	– 0·1	0·0	2·0	+ 2·0	0·6	1·3	+ 0·7	0·4	1·7	+ 1·3	285
300	1·7	0·0	– 1·7	1·1	1·0	– 0·1	0·7	0·6	– 0·1	0·0	2·0	+ 2·0	0·4	1·0	+ 0·6	0·2	0·8	+ 0·6	300
315	1·2	0·0	– 1·2	1·4	0·7	– 0·7	1·0	0·6	– 0·4	0·3	1·7	+ 1·4	0·2	0·8	+ 0·6	0·6	0·6	0·0	315
330	0·6	0·2	– 0·4	1·6	0·5	– 1·1	1·0	0·6	– 0·4	0·6	1·1	+ 0·5	0·0	0·5	+ 0·5	0·9	0·8	– 0·1	330
345	0·4	0·4	0·0	1·1	0·5	– 0·6	1·3	0·6	– 0·7	1·3	1·5	+ 0·2	0·0	0·3	+ 0·3	1·1	1·1	0·0	345

thus obtained should be distributed at random. If, on the other hand, drift II. preponderates in one area, and is deficient in the opposite, the differences would show a maximum at that value of θ_0 which corresponds to the direction of the second drift; and since the numbers are expressed in percentages, a mimimum at the value of θ_0 corresponding to the direction of the first drift.

Table III. shows under A the differences resulting from an examination of the data of Table I. These data include all proper motions irrespective of magnitude. It seemed to us important, however, to show that the differences exhibited in these tables must be due to anomalies inherent in the drift-motions, and cannot be explained by systematic errors in the observational data employed. If they were due to the latter cause, we should naturally expect that by excluding small proper motions their character would become obscured. We have therefore repeated the examination, retaining only the comparatively large proper motions selected by Kobold. The differences based on this material are given in the columns under B. It will be noticed that these differences exhibit the features shown under A even more clearly, and hence we may conclude that the phenomena cannot be explained by the assumption of systematic errors inherent in the observations.

The general conclusion to which these figures point is that between 18^h and 6^h the number of second drift stars is above the average, and between 6^h and 18^h below the average, the maximum density lying approximately in 0^h R.A.

It is much more difficult to fix the declination of the maximum condensation, but an attempt has been made to decide at least whether it is situated in the northern or southern hemisphere. For this purpose the area 22^h to 2^h R.A. and $0°$ to $+30°$ Decl. was compared with the corresponding opposite area 10^h to 14^h R.A. and $0°$ to $-30°$ Decl., the differences being shown in Table IV. under A. A similar comparison was then made between the areas 22^h to 2^h R.A., $0°$ to $-30°$ Decl. and its counterpart, their differences being shown under B.

Table IV.

Differences 12^h–0^h.

θ.	A.	B.	θ.	A.	B.	θ.	A.	B.
0°	+1·3	-1·6	120°	+2·8	+6·3	240°	−4·4	−8·1
15	+1·3	−0·6	135	+0·7	+5·3	255	−3·2	−7·0
30	+1·2	+0·4	150	−1·7	+4·6	270	−2·5	−4·3
45	+2·6	+1·1	165	−2·6	+2·7	285	−2·2	−1·6
60	+4·2	+2·2	180	−1·8	−0·1	300	−1·7	−0·5
75	+5·3	+5·1	195	−2·1	−2·9	315	−0·5	−0·5
90	+5·8	+7·4	210	−3·1	−5·4	330	+0·8	−0·9
105	+4·1	+7·3	225	−4·6	−7·2	345	+1·4	−1·6

It will be noticed that the range of the differences under B is appreciably larger than that under A, and hence it must be inferred that the pole of maximum condensation of the second drift is situated approximately in 0° R.A. and in a *southern* declination. Considering the facts previously found which point to a close relationship between the second drift and the galaxy, we cannot but associate this pole with the southern pole of the galaxy, whose coordinates are 10° R.A. and −27° Decl.

In general, the distribution of drift II. stars within the equatorial belt may be represented by the Fourier series—

$$A + B \cos(a - b) + C \cos 2(a - c) + \ldots .$$

It is obvious that the examination of opposite areas reveals only the odd periodic terms, and that for a numerical discussion of all the terms we have to revert to the figures of Table II. The harmonic analysis of these figures leads to the following numerical expression for the number of drift II. stars—

$$(1)\ 107 + 41 \cos(a + 5^\circ) + 22 \cos 2(a - 111^\circ) - 12 \cos 3(a - 11^\circ),$$

the p.e. of the coefficients being ± 3 units.

The first two terms represent an inequality of the general form $\varepsilon_0 + \epsilon(ax + \beta y + \gamma z)$, such as had been assumed in our analysis of the radial velocities. The third term indicates a tendency of the second drift stars to crowd round two opposite points of the equator of R.A. 7^h and 19^h, *i.e.* very close to the two regions where the galaxy intersects the equator. This intensification of the second drift in the plane of the galaxy is also evidenced by the high percentage of second drift stars in the galactic area, the data for which were given in Table II.

Relationship between the Second Drift and the Galaxy.—One of the most significant results of the preceding investigation is the close association between the stars of the second drift and the Milky Way. Not only have we found distinct evidence that the number of drift II. stars increases when the galactic plane is approached, but the displacement of this plane towards its southern pole is reproduced by a corresponding displacement of the majority of second drift stars in the same direction. It is clear that if galaxy and second drift are the same phenomenon, and if the stars were evenly distributed in this galactic drift, the eccentric position of our system would give rise to an unsymmetrical distribution, the poles of maximum and minimum condensation coinciding exactly with the south and north pole of the galaxy respectively. Applied to the equatorial zone of stars here examined, this would imply that the phase of the second term of the expression (1) should be 10°, viz. the R.A. of the southern galactic pole. The observations show 355°; *i.e.* an apparent displacement of 15° towards the smaller R.A. A difference of this magnitude might perhaps be considered accidental in view of the inherent uncertainties of the material. But if we

come to compare our present result with that obtained from the radial velocities, we must admit that there may be some real significance in this displacement. In our previous paper we found the coordinates of the maximum condensation of the second drift, resulting from the much brighter, and therefore probably nearer, spectroscopic stars, to be 324° R.A. −12° Decl. Here, then, we find a displacement from the galactic pole in the same direction, but much more pronounced. It is not unreasonable to suspect that if this change of phase is real, it might be associated with the average distances of the stars used in both investigations. If, then, we would select stars still nearer to our system than those on which the spectroscopic investigation was based, we should expect a still further displacement in the same direction. Stars of that character have been examined by Dyson, whose research is confined to stars whose proper motions are greater than 20″ per century. We have examined his equatorial regions by the method of opposite areas, and show the results in the following Table V.:—

TABLE V.

θ	0^h %	12^h %	$12^h - 0^h$ Diff.	4^h %	16^h %	$16^h - 4^h$ Diff.	8^h %	20^h %	$20^h - 8^h$ Diff.	θ
0°	0·8	0·5	− 0·3	1·1	0·1	− 1·0	0·6	0·3	− 0·3	0°
15	1·4	0·8	− 0·6	1·3	0·5	− 0·8	0·7	0·4	− 0·3	15
30	1·7	1·2	− 0·5	1·2	1·1	− 0·1	1·3	1·1	− 0·2	30
45	2·2	1·6	− 0·6	1·2	1·6	+ 0·4	2·0	2·0	− 0·0	45
60	4·3	4·1	− 0·2	2·1	2·5	+ 0·4	2·9	2·8	− 0·1	60
75	8·4	8·2	− 0·2	4·3	4·1	− 0·2	4·4	2·8	− 1·6	75
90	11·9	11·6	− 0·3	6·7	6·3	− 0·4	5·9	2·7	− 3·2	90
105	11·6	11·7	+ 0·1	8·4	7·6	− 0·8	5·7	2·3	− 3·4	105
120	8·9	9·3	+ 0·4	8·9	8·5	− 0·4	5·2	3·0	− 2·2	120
135	6·4	6·9	+ 0·5	9·3	8·9	− 0·4	5·8	4·5	− 1·3	135
150	5·8	6·7	+ 0·9	10·2	10·5	+ 0·3	6·0	7·0	+ 1·0	150
165	6·0	7·3	+ 1·3	10·6	12·0	+ 1·4	9·7	10·3	+ 0·6	165
180	6·4	8·1	+ 1·7	10·2	12·5	+ 2·3	11·0	14·5	+ 3·5	180
195	6·8	7·8	+ 1·0	8·6	10·7	+ 2·1	12·5	16·2	+ 3·7	190
210	6·7	5·6	− 1·1	6·6	7·1	+ 0·5	11·7	13·6	+ 1·9	210
225	5·4	3·4	− 2·0	4·5	3·7	− 0·8	8·1	8·5	+ 0·4	225
240	3·2	2·1	− 1·2	2·2	1·3	− 0·9	3·5	4·0	+ 0·5	240
255	1·5	1·7	+ 0·2	0·7	0·7	0·0	0·8	1·9	+ 1·1	255
270	0·2	1·1	+ 0·9	0·1	0·3	+ 0·2	0·1	0·7	+ 0·6	270
285	0·0	0·5	+ 0·5	0·0	0·2	+ 0·2	0·2	0·3	+ 0·1	285
300	0·0	0·1	+ 0·1	0·1	0·0	− 0·1	0·4	0·3	− 0·1	300
315	0·0	0·0	0·0	0·3	0·0	− 0·3	0·6	0·3	− 0·3	315
330	0·1	0·1	0·0	0·6	0·0	− 0·6	0·6	0·2	− 0·4	330
345	0·2	0·4	+ 0·2	0·8	0·0	− 0·8	0·6	0·2	− 0·4	345

The conclusion we draw from the differences shown in this table is that their greatest range occurs not in the 0^h–12^h area, but approximately in the 20^h–8^h area, and hence that the R.A. of the maximum condensation of the second drift is not greater, and probably less, than 300°.

For an explanation of these considerable shifts of the density-pole we have not far to seek. All we have to do is to abandon our assumption that the second drift stars are evenly distributed in the galactic plane. In fact, a casual inspection of the apparent structure of the galaxy in the heavens militates at once against such an assumption. It is a well-known fact that the galaxy is very much denser and brighter between roughly 270°–0°–90°, than between 90°–180°–270° galactic longitude, and this fact suggests at once the existence of a condensation in the galaxy itself. The actually observed pole of greatest density is therefore the resultant of two poles: one caused by the eccentric position of our system, and coinciding with one of the poles of the galaxy; the other caused by an uneven distribution of stars in the Milky Way, and therefore coinciding with its densest region. The observed density pole will lie on the great circle joining these two poles, and its position in this great circle will be determined by the relative strength of the two condensations, which, according to the observed facts, appears to depend largely on the parallax.

The coordinates of the observed pole of maximum condensation for the spectroscopic stars were found R.A. − 324°, Decl. − 12°. According to the preceding explanation, the great circle joining this point with the south pole of the galaxy should intersect the galactic ring at its densest region. The coordinates of the point of intersection are R.A. 285°, Decl. +9°. This point is near the centre of the great bifurcation characterised by the strongest condensations of the galactic cloud, and in vivid contrast to the diametrically opposite region, where the Milky Way is very feebly represented.

General conclusion.—In the light of the preceding results, we venture to offer the following hypothesis with regard to the structure of the visible universe.

Two distant aggregations of stars have to be distinguished:

1. A uniformly distributed arrangement of stars, the individual members of which may be assumed to be endowed with chance motions, but not with any systematic motion common to the drift in its entirety. (Kapteyn's first drift.)

2. A drift of stars similar in structure to, and probably identical with, the galaxy, endowed with a common but not entirely uniform motion towards a point, the so-called relative vertex of the two drifts. (Kapteyn's second drift.)

On this hypothesis the motion of our system would be in a direction exactly opposite to the apparent motion of the first drift, and hence towards a point in R.A. 267°·0 and Decl. +13°.

Effect of unequal distribution of the two Drifts on the Constant of Precession.—If we had to deal with a homogeneous mixture of

stars of the two drifts, the effect, so far as precession is concerned, would be the same as that of a single drift. Using the notations adopted in our first paper (p. 97 (5)), the components of the transverse proper motion in R.A. and Decl. are represented by the following equations:—

$$\left.\begin{aligned}\mu_\alpha \cos\delta &= \Delta m \cos\delta - \left[V_1 L - \frac{\Delta n}{\varpi} \sin\delta \right] \varpi \sin\alpha + V_1 M \varpi \cos\alpha \\ \mu_\delta &= V_1 N \varpi \cos\delta + \left[\frac{\Delta n}{\varpi} - V_1 L \sin\delta \right] \varpi \cos\alpha - V_1 M \varpi \sin\delta \sin\alpha \end{aligned}\right\} (1)$$

Here Δm, Δn denote the corrections to the adopted precessional constants m, n, and ϖ is the mean stellar parallax.

These formulæ, which are identical with those of Airy, assume a much more complicated form if we introduce the hypothesis of unequal mixture of the two drifts. Let α, β, γ be the direction cosines of the pole of maximum condensation of drift II., ξ, η, ζ those of the relative vertex, V'_1 the resultant velocity of the one drift with respect to the other, and ϵ the coefficient of condensation, then our formulæ become—

$$\left.\begin{aligned}\mu_\alpha \cos\delta = {} & \Delta m \cos\delta + \tfrac{1}{2}\epsilon V'_1 [\alpha\eta - \beta\xi] \varpi \cos\delta \\ & - \left[V_1 L - \frac{\Delta n}{\varpi} \sin\delta + \epsilon V'_1 \gamma\xi \sin\delta \right] \varpi \sin\alpha \\ & + [V_1 M + \epsilon V'_1 \gamma\eta \sin\delta] \varpi \cos\alpha \\ & + \tfrac{1}{2}\epsilon V'_1 [\alpha\eta + \beta\xi] \varpi \cos\delta \cos 2\alpha \\ & - \tfrac{1}{2}\epsilon V'_1 [\alpha\xi - \beta\eta] \varpi \cos\delta \sin 2\alpha ; \\ \mu_\delta = {} & V_1 N \varpi \cos\delta - \tfrac{1}{4}\epsilon V'_1 [\alpha\xi + \beta\eta - 2\gamma\zeta] \varpi \sin 2\delta \\ & + \left[\frac{\Delta n}{\varpi} - V_1 L \sin\delta + \epsilon V'_1 \alpha\zeta \cos^2\delta - \epsilon V'_1 \gamma\xi \sin^2\delta \right] \varpi \cos\alpha \\ & - [V_1 M \sin\delta - \epsilon V'_1 \beta\zeta \cos^2\delta + \epsilon V'_1 \gamma\eta \sin^2\delta] \varpi \sin\alpha \\ & - \tfrac{1}{4}\epsilon V'_1 [\alpha\xi - \beta\eta] \varpi \sin 2\delta \cos 2\alpha \\ & - \tfrac{1}{4}\epsilon V'_1 [\alpha\eta + \beta\xi] \varpi \sin 2\delta \sin 2\alpha. \end{aligned}\right\} (2)$$

We propose to examine these formulæ on the basis of Newcomb's discussion of the Bradley proper motions published in his paper "A new determination of the Precessional Constant with the resulting Precessional Motions," *Astron. Papers, American Ephemeris*, vol. viii.

First, as regards α, β, γ, the direction cosines of the pole of maximum condensation of drift II., we remember that this pole was found to be situated in R.A. 0^h. Its declination could not be fixed with certainty. From the radial velocities we found $-12°$, hence γ must be small; and further considering that in equations (2) it appears multiplied into $\sin\delta$ and $\sin^2\delta$, its effect will most likely be negligible. We may then assume $\alpha = 1$, $\beta = 0$, $\gamma = 0$.

Secondly, with regard to ξ, η, ζ, the direction-cosines of the

relative vertex of the two drifts, we found that for the Bradley stars this vertex is situated very nearly at 270° R.A. and on the equator. Hence, with sufficient approximation, $\xi = 0$, $\eta = -1$, $\zeta = 0$.

The component velocities V_1L, V_1M, V_1N may be taken from our first paper (p. 101); they are respectively $-0{\cdot}4$, $+18{\cdot}8$, $-9{\cdot}0$ kms. per second. The same investigation also furnishes us with the value of

$$\epsilon V'_1 = 7{\cdot}8 \text{ kms./s.}$$

The remaining quantity ϖ may be found from the equation

$$\varpi = \frac{1}{V_1}\sqrt{\frac{X^2+Y^2}{L^2+M^2}}$$

where X and Y represent the components of the Sun's motion in the plane of the equator given in Newcomb's discussion (see p. 40 of his paper). We find

$$\varpi = \sqrt{\frac{0{\cdot}12^2+2{\cdot}71^2}{0{\cdot}4^2+18{\cdot}8^2}} = 0{\cdot}144\,;$$

and hence $\epsilon V'_1 \varpi = 1''{\cdot}12$. Substituting all these quantities into equations (2) and neglecting the small term V_1L we obtain—

$$\left.\begin{aligned} \mu_\alpha \cos\delta &= (\Delta m - 0''{\cdot}56)\cos\delta + \Delta n \sin\delta \sin\alpha + 2''{\cdot}71\cos\alpha \\ &\quad - 0''{\cdot}56\cos\delta\cos 2\alpha \\ \mu_\delta &= -1''{\cdot}30\cos\delta + \Delta n\cos\alpha - 2''{\cdot}71\sin\delta\sin\alpha \\ &\quad + 0''{\cdot}28\sin 2\delta\sin 2\alpha \end{aligned}\right\} \quad . \quad (3)$$

Now if we make the same substitutions into equations (1), in which the two drifts are considered homogeneous, we find—

$$\left.\begin{aligned} \mu_\alpha\cos\delta &= \Delta m\cos\delta + \Delta n\sin\delta\sin\alpha + 2''{\cdot}71\cos\alpha \\ \mu_\delta &= -1''{\cdot}30\cos\delta + \Delta n\cos\alpha - 2''{\cdot}71\sin\delta\sin\alpha \end{aligned}\right\} \quad . \quad (4)$$

We notice, therefore, two important changes in the equation for $\mu_\alpha \cos\delta$, viz. that Δm is replaced by $\Delta m - 0''{\cdot}56$, and a new term is introduced depending on the cosine of the double right ascension.

If, then, our hypothesis of an unequal distribution of the two drifts be correct, we ought to find evidence of these new terms in Newcomb's discussion.

It is well known that Newcomb was unable to reconcile the values which he derived for δp, the correction to his adopted luni-solar precession, from a separate discussion of the right ascensions and declinations. The values he obtained were—

$$\delta p = +0''{\cdot}24 \text{ from R.A.}$$
$$\delta p = +1''{\cdot}12 \text{ from Decl.}$$

The latter value remains unaffected in our equations, as is readily seen from (3) and (4). But to obtain δp from the R.A. we have now to adopt the modified equation—

$$(\delta p \cos \epsilon - 0''\cdot56) = +0''\cdot24 \cos \epsilon, \text{ or } \delta p = +0''\cdot85.$$

The difference is therefore reduced from $0''\cdot88$ to $0''\cdot27$. There is, of course, still an uncertainty as to the correction to the adopted equinox. Newcomb's conclusion is that this correction would probably increase the value of δp by $+0''\cdot33$, so that we should have—

$$\delta p = +1''\cdot18 \text{ from R.A.}$$
$$+1''\cdot12 \text{ from Decl.}$$

The results of L. Struve fully bear out our conclusions. If we adopt the final values of p (1800) derived by him in his paper in *Ast. Nach.* 3816 from a discussion of the Bradley-Pulkowa stars situated between $\pm 15^\circ$ declination, which for reasons stated in his paper probably represent the best determinations obtainable, and if we further consider that, judging by his values of X and Y, the parallactic factor is about 1·27 of that adopted in Newcomb's reductions, we find that Struve's p derived from R.A. should be enlarged by $0''\cdot77$ on account of the term $\frac{1}{2}\epsilon V'_1 \varpi \ [\alpha\eta - \beta\xi]$ of equation (2). Taking further into account a possible correction, ν, to the equinox of Newcomb's system, we obtain—

Newcomb: p (1800)	$-$	$5036''\cdot62 + 1\cdot09\,\nu$	(from R.A.)
		$5036''\cdot89$	(from Decl.)
L. Struve: p (1800)	$-$	$5036''\cdot48 + 1\cdot09\,\nu$	(from R.A.)
		$5036''\cdot56$	(from Decl.)

By our hypothesis the serious discrepancy between the results obtained from right ascensions and declinations is therefore completely removed.

As regards the evidence pointing to the existence of the term $(-0''\cdot56 \cos \delta \cos 2\alpha)$ of equation (3) we refer to the interesting passage on pp. 40–43 of Newcomb's work, where he shows conclusively the presence of residuals which are satisfied by a term $(-0''\cdot50 \cos \delta \cos 2\alpha)$. In absence of any other explanation, he is inclined to attribute the cause of it to systematic errors in Bradley's right ascension, although he carefully adds "that so large an error as this could have affected Bradley's observations certainly seems unlikely." The close agreement in amplitude and phase with the term theoretically anticipated in equation (3) seems to us, however, a most satisfactory proof of the reality of our hypothesis.

No attempt has been made to discover the existence of the similar term in the equation for μ_δ, the detection of which is rendered almost hopeless by the much smaller amplitude and the presence of the factor $\sin 2\delta$.

Summary.

(1) In a previous paper, an investigation of the systematic distribution of the radial velocities of stars as determined by spectroscopic methods revealed phenomena which could not be explained by the two-drift hypothesis of Kapteyn in its original form.

(2) Kobold's discussion of the transverse proper motions of the Bradley stars suggested an amendment to this hypothesis, viz. an inequality in the distribution throughout the sky of one or both drifts, by which the anomalies met with in the radial velocity investigation could apparently be completely reconciled.

(3) To ascertain how far this amendment was borne out, a closer investigation of the transverse proper motions of the Bradley stars has been undertaken in the present communication, with the results that—

(4) The anomalous distribution as regards position and motion seems to be restricted to the second drift.

(5) The distribution of second drift stars, and likewise their motions, are of a highly complex character: the evidence derived from the Bradley stars shows that the geometrical structure of this drift has many features in common with that of the Milky Way, and suggests the possible identity of this drift with the galaxy.

(6) The simple hypothesis by which the inequality of distribution was represented in order to reconcile the radial velocity phenomena serves also to explain the anomalous discordances found between the values of the precessional constant derived from proper motions in R.A. and in Decl. respectively, and also to explain both qualitatively and quantitatively the existence of a periodic inequality found by Newcomb in this constant as derived from groups of stars in different right ascensions.

Solar Parallax Papers. No. 9.

The general solution from the Micrometric Right Ascensions of Eros, at the opposition of 1900. By Arthur R. Hinks, M.A.

§ 1. In accordance with the recommendations of the Eros Commission (Astrographic Congress, Paris, 1900), a large number of observers made micrometric comparisons between the planet and neighbouring stars. A considerable part of these results are published in the Paris Circulars. Several important series are, however, incompletely published, or not published at all. I am indebted to Professor Hermann Struve, formerly Director of the Koenigsberg Observatory, for the communication in manuscript of the results of his measures; to Professor Campbell and Dr. Aitken, of the Lick Observatory, for the results of the measures made there by Messrs. Aitken and Hussey: and to Captain Barnette, U.S.N., Superintendent of the Naval Observatory,

Washington, for the measures made there by Professor See, and reduced by Mr. Frederick. In these three cases I was able to communicate to the observatories concerned the places of most of the comparison stars which had been used; these places were derived from my standard photographic catalogue. I greatly regret that the series made by Professor Barnard at the Yerkes Observatory, and by Professor Comstock at the Washburn Observatory, have been published only in the rough, and never reduced. I was unable to undertake the considerable task of completely reducing these two series, and have therefore been unable to use them. For the same reason I have been unable up to the present to utilise the shorter series made at Charlottesville, Cordoba, Edinburgh, Marseilles, of which the published reductions are incomplete.

§ 2. The method of reduction follows closely on the lines laid out in the treatment of the photographic results (*S.P.P.* No. 7, §§ 4, 7, 8, 9, *M.N.*, 1909 May, vol. lxix., No. 7, p. 544 *et seq.*).

To the published values of O – C in right ascension I have applied corrections—

(*a*) To reduce the adopted place of the comparison star to my standard photographic system.

(*b*) To eliminate the terms of short period in the nutation, when these had been improperly introduced (*loc. cit.*, § 7).

(*c*) To reduce to the new Paris ephemeris (*loc. cit.*, § 9).

(*d*) To eliminate the tabular error of this ephemeris, as determined from the photographs (Tabular error No. 3).

Each published value of O – C, thus corrected, reduces to a small numerical quantity m, and our equation of condition is

$$\Delta\alpha + a\mathrm{P} + m = 0$$

where $\Delta\alpha$ is the residual tabular error.

a the correction for parallax computed with

$$\pi = 8''{\cdot}80.$$

$1 + \mathrm{P}$ the factor with which the assumed parallax requires to be multiplied.

§ 3. The observations are of two kinds:—

A. Micrometric comparisons properly so called, in which the planet is referred to the star by observations of distance and position angle, or of difference of rectangular coordinates, measured with the filar micrometer within the limits of the field of view, the telescope being driven. We shall call these briefly "measures."

B. Micrometric comparisons made by the method of transits, registered on the chronograph, the telescope remaining fixed during the comparison. We shall call these briefly "transits."

We must distinguish sharply between the two categories. The first is not liable, *a priori*, to systematic error. The second is

certain to be affected by the well-known "magnitude equation" whenever the magnitudes of planet and star are not precisely the same. And on this ground we may expect that the measures will be better than the transits.

On the other hand, the motion of the planet during the night was so large that it was hardly ever possible to make measures to the same star evening and morning. With the method of transits this was usually possible. Hence to this extent transits have the advantage over measures.

The transits, however, are more affected than are the measures by instability in the instrument, maladjustment of the polar axis, and so on.

§ 4. The instruments and methods employed were so varied that it was impossible to form any *a priori* scale of weights. But inasmuch as $\Delta\alpha$ and P are both small, the average value of m in the equations of condition gave a preliminary criterion of the quality of each series.

It was easy to see that a considerable number of observations would have to be rejected on the ground of large and inexplicable discordances. But no precise rule could be laid down for this rejection. A group of four or five comparisons might generally give systematically large values of m; but among them one comparison would give a more normal value. It might be absurd to reject four consistently high comparisons, and leave in the one which was divergent from its companions, though giving a small value of m. Each case was considered in relation to its surroundings, and it is impossible in a brief space to give full details. Criticism of the rejections must therefore be held over till the equations of condition are printed.

When the larger discordances had been separated from the rest, the following conclusions were found to be approximately true:—

(1) There was very little relation between the value of m and the number of comparisons upon which it depended: immediate repetition of the comparison had contributed little to eliminate the errors. This was to be expected, since many factors affected the comparison, especially the assumed places of the stars. I therefore decided that it was not worth while to weight the equations according to the number of comparisons.

(2) On the other hand, it was evident that roughness of the star places was not primarily responsible for the considerable roughness of the values of m in some series. And it was impossible to assign precise relative weights to the assumed places of the stars. I therefore decided that it was not worth while to weight the equations according to the supposed weights of the star places upon which they depended.

(3) The comparisons with the ephemeris, O – C, were published in seconds of time. One might consider it necessary to multiply each by the cosine of the corresponding declination before introducing it into the equations of condition. But against this was to be put the fact that the observations in the lower declinations,

with higher values of $\cos\delta$, were made in general at greater zenith distances, and hence under circumstances less favourable to precision. This would introduce a compensation. I therefore decided that it was not worth while to introduce the factor $\cos\delta$ into each equation, but that it would be sufficient to weight appropriately the final solutions for the different groups into which the observations were to be separated.

§ 5. We will now treat separately the two categories, Measures and Transits, as defined above.

Preliminary System of Weights for the Measures.

The material is as follows:—

Koenigsberg has 346 observations; average value of m $0^s{\cdot}023$. Of these, 10 were first marked as discordant, the lowest values so marked being ·072 and ·074, and their average ·093.

The average value of the remaining 336 was ·021.

Instrument: 13-inch refractor. Professor Hermann Struve and Dr. Postelmann.

Lick has 235 observations; average value of m $0^s{\cdot}035$; 50 excluded as discordant, generally all over ·065, the average being ·084. There remain 185 with average value ·022. In several cases it has been necessary to reject complete series of these measures, for discordance due to some abnormal cause. Dr. Aitken and the writer have spent much trouble in searching for this cause, but without success.

36-inch refractor. Professor Hussey and Dr. Aitken.

Lyon has 78 observations; average value of m $0^s{\cdot}047$. 14 excluded, lowest ·078 and ·084, average ·135; 64 remain, average ·027.

$0^m{\cdot}32$ equatorial coudé; MM. André, Guillaume, and Le Cadet.

Nice (M. Perrotin) has 42 observations, average value of m $0^s{\cdot}036$, of which one only, ·108, is rejected as discordant. The greater part of M. Perrotin's observations were transits. (See later.)

$0^m{\cdot}76$ refractor.

Nice (M. Charlois) has 29 observations, average of m $0^s{\cdot}087$; 6 discordant, lowest ·137 and ·140, average ·184. 23 retained average ·061.

$0^m{\cdot}32$ equatorial coudé.

Nice (M. Prim) has 41 observations, average of m $0^s{\cdot}089$; 7 discordant, lowest ·140 and ·149, average ·200; 34 retained, average ·066.

$0^m{\cdot}32$ equatorial coudé.

Paris (M. Bigourdan) has 93 observations, average of m $0^s{\cdot}064$; 12 discordant, lowest ·118 and ·137, average ·194; 81 retained, average ·045.

$0^m{\cdot}30$ refractor.

Paris (M. Fayet) has 62 observations, average of m $0^s{\cdot}076$; 11 discordant, lowest ·124 and ·139, average ·190; 51 retained, average ·050.

$0^m{\cdot}30$ refractor.

Pulkovo has 26 observations, average of m $0^s{\cdot}064$; 7 discordant, lowest ·106 and ·121, average ·161; 19 retained, average ·028.

30-inch refractor, M. Renz. 15-in. refractor, M. Sokolov and M. Seraphimov.

Contrary to expectation, there seems to be little difference in the accuracy given by the two instruments.

Teramo has 259 observations, average of m $0^s{\cdot}041$; 20 discordant, lowest ·092 and ·093, average ·118; 239 retained, average ·034.

15-inch refractor, M. Cerulli.

Washington has 188 observations, average of m $0^s{\cdot}028$. The greatest discordances are ·078 and ·082, and all have been retained.

26-in. refractor, Professor T. J. J. See.

Upon consideration of this material, I derived the preliminary system of weights given in my *Rapport sur la détermination de la parallaxe solaire.* (Procès verbaux de la Carte du Ciel, 1909.) After the preliminary solutions then given had been made, the whole material was overhauled; some cases of discordance referred to authors; some mistakes found in the reductions; and the revised equations were collected for the final solutions.

§ 6. Three different systems of weights have been used at various times: the preliminary, as above; System I., that finally adopted; System II., used alternatively in part of the discussion which follows. They are given in the following table:—

	Weights.		
	Preliminary.	System I.	System II.
Koenigsberg	3	3	3
Lick	3	3	2
Lyon	2	2	1
Nice (Perrotin)	2	2	2
Nice (Charlois)	1	1	1
Nice (Prim)	1	1	1
Paris (Bigourdan)	1	2	2
Paris (Prim)	1	1	1
Pulkovo	2	2	1
Teramo	2	3	1
Washington	3	3	1

§ 7. The solutions are of two kinds—those covering a limited

period, and including material from all observatories; and those covering a more extended period, but confined to one observatory.

The periods were defined, as in much of the preceding work, by the vanishing points of the lunar equation. Observations before 1900 Oct. 1 are very scattered, and have not been used. Observations after 1901 Jan. 14 are so unsymmetrical in parallax factors that they also have been excluded.

We have then 8 groups, defined in date thus:—

Group	0.	1900 October 1–10
	I.	October 11–23
	II.	October 24–November 6
	III.	November 7–19
	IV.	November 20–December 2
	V.	December 3–17
	VI.	December 18–31
	VII.	1901 January 1–14

and we have to solve in each group for $\Delta\alpha$ and for P.

§ 8. **Solution I.—Groups.** Weights: System I.

Group.	$\Delta_0\alpha$.	P.	Weight.
0.	$+0^s\cdot01150$	$-0\cdot00251$	91
I.	− 395	+ 51	345
II.	− 330	+ 154	1301
III.	− 382	− 166	1194
IV.	+ 98	+ 56	1146
V.	+ 604	− 72	1290
VI.	+ 752	+ 334	695
VII.	− 34	+ 50	490

and combining these results according to their weights we obtain

$$P = +\cdot000343 \pm \cdot000389,$$

whence $\pi = 8''\cdot803 \pm \cdot0034$

§ 9. **Solution II.**—Adding together the normal equations for the above eight groups, and forming one pair of normals for the whole material, we have—

$$\Delta_0\alpha = +\cdot00154 \qquad P = +\cdot00088 \qquad \text{wt. } 7102,$$

whence $\pi = 8''\cdot808.$

§ 10. Treating the four series of weight 3 separately in the same way we have—

Solution IIIa.—Koenigsberg.

Group.	$\Delta_0\alpha$.	P.	Wt.
O.	$-0^s\cdot00222$	$-\cdot02116$	10
I.	No solution possible		
II.	$-\cdot01300$	$-\cdot00726$	39
III.	-307	-214	1
IV.	$+1526$	-1039	65
V.	$+1283$	-395	57
VI.	$+1872$	$+858$	52
VII.	$+53$	-188	92

whence $P = -\cdot00356 \pm \cdot00187$

$\pi = 8''\cdot769 \pm ''\cdot0165.$

Or, adding the groups together and solving *en bloc*,

$\Delta_0\alpha = +\cdot00411$ $P = -\cdot00089$ wt. 420×3.

Solution IIIb.—Lick.

Group.	$\Delta_0\alpha$.	P.	Wt.
II.	$+0^s\cdot00134$	$+\cdot00434$	201
III.	-2461	$+366$	140
IV.	-765	$+446$	124
V.	-671	$+711$	133
VI.	-862	$+1077$	29

whence $P = +\cdot00510 \pm \cdot00059$

$\pi = 8''\cdot845 \pm ''\cdot0052.$

Or, adding the groups together and solving *en bloc*,

$\Delta_0\alpha = -0^s\cdot00766$ $P = +\cdot00450$ wt. 647×3.

Solution IIIc.—Teramo.

Group.	$\Delta_0\alpha$.	P.	Wt.
O.	$+0^s\cdot02205$	$+\cdot00514$	4
I.	-100	$+579$	30
II.	-479	$+189$	94
III.	$+711$	-369	58
IV.	$+925$	-203	50
V.	$+1286$	-840	75
VI.	-692	$+810$	51
VII.	-234	-164	20

whence $P = -\cdot00051 \pm \cdot00140$

$\pi = 8''\cdot796 \pm ''\cdot0123.$

Or, adding the groups together and solving *en bloc*,

$$\Delta_0\alpha = +0^s\cdot00186 \qquad P = -\cdot00052 \qquad \text{wt. } 436\times3.$$

Solution IIId.—Washington.

Group.	$\Delta_0\alpha$.	P.	Wt.
O.	$+0^s\cdot01203$	$+\cdot01131$	15
I.	$-$ 1065	$-$ 253	67
II.	$-$ 1059	$-$ 420	60
III.	$-$ 1154	$-$ 869	30
IV.	$-$ 973	$+$ 465	62
V.	$+$ 1225	$+$ 189	61
VI.	$-$ 1100	$-$ 2400	2
VII.	$-$ 559	$+$ 787	10

whence $P = -\cdot00025 \pm \cdot00180$

$\pi = 8''\cdot798 \pm ''\cdot0158.$

Or, adding the groups together and solving *en bloc*,

$$\Delta_0\alpha = -0^s\cdot00205 \qquad P = -\cdot00026 \qquad \text{wt. } 342\times3.$$

It is not worth while to split up the series from other observatories into eight groups, as is done above. It will suffice to make the *en bloc* solutions. Collecting the results of these, and including the four given immediately above, we have—

Solution III.—Observatories. Weights: System I.

Observatory.	$\Delta_0\alpha$.	P.	Wt.
Koenigsberg	$+0^s\cdot00411$	$-\cdot00089$	1260
Lick	$-$ 766	$+$ 450	1941
Lyon	$+$ 592	$-$ 1011	198
Nice (Perrotin)	$+$ 1535	$-$ 171	106
Nice (Charlois)	$-$ 532	$+$ 1274	56
Nice (Prim)	$+$ 969	$-$ 965	71
Paris (Bigourdan)	$+$ 1882	$+$ 837	142
Paris (Fayet)	$-$ 197	$+$ 688	10
Pulkovo	$-$ 37	$-$ 1171	54
Teramo	$+$ 186	$-$ 52	1308
Washington	$-$ 205	$-$ 26	1026

whence $P = +\cdot000832 \pm \cdot000817$

$\pi = 8''\cdot807 \pm ''\cdot0072.$

If we assign weights according to system II. we have—

$\pi = 8''\cdot806.$

§ 11. We have now to examine the point raised in § 4 (3); the effect of weighting down each comparison in R.A. by cos δ, and thus reducing it to a comparison in arc on the great circle.

We shall obtain very nearly the same result if we weight down each group O.—VII. by the value of $\cos^2\delta$ corresponding to the mean declination of the group. These values are:—

Group.	$\cos^2\delta$.	Group.	$\cos^2\delta$.
O.	·46	IV.	·38
I.	·40	V.	·47
II.	·34	VI.	·56
III.	·34	VII.	·67

If we weight the group contributions to Solution I. in this way we have, as the modified result:—

Solution IV.—Groups. Weights: System I × $\cos^2\delta$.

$$P = +\cdot000446 \pm \cdot000398$$
$$\pi = 8''\cdot804 \pm ''0035.$$

And similarly, as the modification of Solution II., we have

Solution V.

$$P = +\cdot00095$$
$$\pi = 8''\cdot808.$$

Finally, as the modification of Solution III. we have:—

Solution VI.—Observatories. Weights: System I × $\cos^2\delta$.

Observatory.	$\Delta_0\alpha$.	P.	Wt.
Koenigsberg	$+0^s\cdot00458$	$-\cdot00090$	606
Lick	− 739	+ 487	750
Lyon	+ 636	− 1105	84
Nice (Perrotin)	+ 1376	− 73	42
Nice (Charlois)	− 703	+ 1156	28
Nice (Prim)	+ 558	− 861	34
Paris (Bigourdan)	+ 1962	+ 855	62
Paris (Fayet)	− 623	+ 942	3
Pulkovo	+ 121	− 978	26
Teramo	+ 164	− 43	558
Washington	− 126	+ 14	414

whence $P = +\cdot000882 \pm \cdot000837$

$$\pi = 8''\cdot808 \pm ''\cdot0074.$$

Or if we adopt weights according to System II. × $\cos^2\delta$ we have

$$\pi = 8''\cdot806.$$

The results of Solutions IV. to VI. are so little different from the corresponding Solutions I. to III. that it is clear that it is practically immaterial whether we introduce the factor cos δ or not. And we have found reason for thinking it is better left out. Hence we shall discard Solutions IV. to VI. in what follows.

§ 12. *Preliminary Examination of the Transits.*

The comparisons between planet and stars by the method of transits are affected by magnitude equation; and it is impossible to say *a priori* how large this effect may be. At a first glance it is clear that the numerical terms m in the equations of condition for Transits are much larger than for Measures. Before we can frame any rules for the rejection of observations, or make any assignment of weights, we must try to find how much of this apparent roughness is legitimate, due to magnitude equation, and how much is real roughness of observation.

The very fine series of transits made by Perrotin at Nice with the great refractor provides valuable material for this purpose. Perrotin generally observed to the same stars morning and evening; his observations of this class up to 1900 December 31 are called Pairs. Other observations in the same period, which lack the complementary observations evening or morning, are called Odd. All observations made after 1901 January 1 are called Late.

Classifying the equations of condition according to the sign and size of their numerical terms, we have:—

Classification of m *in Equations from Nice Transits.*

	Pairs.		Odd.		Late.	
m	+ve	−ve	+ve	−ve	+ve	−ve
s·000 to s·010	26	34	9	9	13	15
11 ,, 20	17	25	5	8	11	16
21 ,, 30	20	19	6	7	13	12
31 ,, 40	13	31	7	7	12	11
41 ,, 50	16	23	3	2	8	12
51 ,, 60	15	17	5	4	10	9
61 ,, 70	17	14	9	5	7	13
71 ,, 80	13	12	1	3	6	2
81 ,, 90	6	9	3	1	5	7
91 ,, 100	7	7	5	1	2	0
101 ,, 110	5	8	2	2	2	5
111 ,, 120	5	2	3	2	6	1
121 ,, 130	2	1	3	0	1	0
131 ,, 140	1	2	2	1	0	0
141 ,, 150	1	3	2	0	1	0
151 ,, 160	2	0	0	0	0	0
161 ,, 170	0	2	0	0	0	1
>170	3	3	4	3	3	1

There is no striking dissymmetry between +ve and −ve; and such data as we possess concerning the magnitude of the planet make it not far from the mean magnitude of the comparison stars employed at Nice. The values of m are more scattered than if they were accidental—and it may be remarked that no permissible correction to the parallax would produce much visible effect in this rough view—but the extra diffuseness does not seem to extend beyond $\pm^{s}\cdot100$. I think that we may conclude—

(1) That magnitude equation is not the preponderating cause in making the values of m large.

(2) That its effects are nearly confined within the limits $\pm^{s}\cdot100$ at most.

(3) And that we should reject as discordant all observations giving a value of m greater than $\pm^{s}\cdot160$.

A similar examination of the material furnished by Arcetri, Besançon, and Teramo led to very nearly the same results, and to the same rule for rejection.

§ 13. It is desirable to obtain confirmation of the first conclusion, that magnitude equation is not a preponderating cause. With this purpose I have examined the differences in pairs of comparisons with the same star, one taken east and one west. If the numerical terms m are mainly accidental, the average differences should be about $\sqrt{2}$ times the average value of a single m; the existence of sensible magnitude equation will make the differences of pairs small compared with the single values. The existence of a sensible correction to the parallax will have little effect. The observations of Nice, before any had been rejected for discordance, were divided into groups as above, and the following averages were obtained:—

Nice:

Group.	Average m for "Pairs."		$\times\sqrt{2}$.	Average Diff. E. W.		Average m for "Odds."	
O.	22	$^{s}\cdot056$	$^{s}\cdot079$	9	$^{s}\cdot090$	4	$^{s}\cdot048$
I.	62	67	94	26	90	10	148
II.	8	85	120	4	133		
III.	33	36	51	15	27	19	39
IV.	62	48	68	29	62	15	59
V.	148	46	65	71	59	44	76
VI.	46	40	56	21	53	31	40
Totals	381	50	70	175	64	123	64

The small figures give the number of observations contributing to each average.

It appears that the average difference of two m's is decreased from $^{s}\cdot070$ to $^{s}\cdot064$ if the two are selected comparisons with the same star, one E. and one W. This confirms the conclusion of the preceding paragraph, that magnitude equation enters, but not with great effect.

§ 14. We may now summarise the material for discussion as follows:

Transits.—Nice (M. Perrotin) has 489 comparisons retained, with an average value of m $^{s}\cdot048$, and 15, above $^{s}\cdot160$, rejected. Instrument $0^{m}\cdot76$ refractor.

Padova (M. Antoniazzi) has 122 retained, average $^{s}\cdot045$, and 8 rejected. $0^{m}\cdot19$ refractor.

Besançon (M. Chofardet) has 47 comparisons retained, average m ·069, and 8 rejected. $0^{m}\cdot32$ equatorial coudé.

Pulkovo (MM. Renz, Sokolov, and Seraphimov) has 51 comparisons retained, average $^{s}\cdot034$, and none rejected. 30-in. and 15-in. refractors.

Arcetri (M. Abetti) has 15 comparisons retained, average ·089, and 10 rejected. $0^{m}\cdot28$ refractor.

Christiania (MM. Geelmuyden and Schroeter) has 6 comparisons retained, average $^{s}\cdot026$, and none rejected. $0^{m}\cdot19$ refractor.

The above figures refer to comparisons in R.A. made before 1901 Jan. 1. After that date the observations become so unsymmetrical in respect to parallax factor that I have thought it better to exclude them from the discussion.

It appears that the two principal series, from Nice and Padova, though made with instruments of very different powers, deserve the same weight. Of the other series, some are apparently more self-accordant than these and some less. But I do not think that these shorter series are long enough to furnish reliable determinations of their weight, or substantial contributions to the parallax determination. I have therefore not assigned to them weights different from the rest.

§ 15. The Nice series is so much more complete than the rest that we will first solve for it alone.

The form of the equation of condition is the same as before.

We shall make three solutions:—

(*a*) Including only those equations which arise from comparisons with the same star evening and morning. But it should be noted that the number of comparisons is not always the same evening and morning, and that in general the parallax factors are not symmetrical. Hence the error in the assumed place of the star is not entirely eliminated in this solution.

(*b*) Including all the equations.

(*c*) A solution in which the place of the star is strictly eliminated as follows: The equations corresponding to one comparison star are divided into two groups, evening and morning. The mean of the group having the greater number of equations is multiplied by the factor required to reduce it to the weight of the group having the lesser number of equations. The coefficients of $\Delta\alpha_0$ are then the same in both, and when one is subtracted from the other we have an equation in P with a coefficient corresponding to its weight. The sum of all such equations in P belonging to any period of fourteen days gives the solution for that period.

The results of these solutions are as follows:—

Solution VIIa.—Nice Transits. "Pairs" only.

Group.	$\Delta_0 a$.	P.	Wt.
O.	$+0^s{\cdot}0142$	$-{\cdot}0258$	24
I.	$-\ 299$	$-\ 205$	99
II.	$-\ 388$	$-\ 429$	18
III.	$+\ 26$	$+\ 57$	112
IV.	$-\ 18$	$+\ 108$	137
V.	$+\ 87$	$+\ 82$	330
VI.	$+\ 64$	$-\ 65$	87

whence $P = +{\cdot}00104 \pm {\cdot}00357$

$\pi = 8''{\cdot}809 \pm ''{\cdot}031.$

Solution VIIb.—Nice Transits. All.

Group.	$\Delta_0 a$.	P.	Wt.
O.	$+0^s{\cdot}0144$	$-{\cdot}0261$	27
I.	$-\ 204$	$-\ 243$	108
II.	$-\ 388$	$-\ 429$	18
III.	$+\ 15$	$+\ 43$	171
IV.	$-\ 29$	$+\ 115$	172
V.	$-\ 11$	$+\ 85$	404
VI.	$-\ 31$	$-\ 7$	141

whence $P = +{\cdot}00187 \pm {\cdot}00348$

$\pi = 8''{\cdot}816 \pm ''{\cdot}031.$

Solution VIIc.—Nice Transits. "Morning—Evening."

Group.	$[aa.]$	$[am.]$	
O.	$+\ 67{\cdot}25\ P$	$+\ 1{\cdot}656 = 0$	$P = -{\cdot}0247$
I.	$337{\cdot}91$	$+\ 9{\cdot}768$	$-\ 289$
II.	$75{\cdot}52$	$+\ 3{\cdot}256$	$-\ 431$
III.	$623{\cdot}46$	$-\ 1{\cdot}812$	$+\ 29$
IV.	$641{\cdot}19$	$-\ 7{\cdot}402$	$+\ 115$
V.	$1819{\cdot}69$	$-15{\cdot}493$	$+\ 85$
VI.	$441{\cdot}87$	$+\ 2{\cdot}516$	$-\ 57$

whence $P = +{\cdot}00188 \pm 00361$

$\pi = 8''{\cdot}816 \pm {\cdot}032.$

§ 16. These observations had been submitted to a preliminary reduction by their author, the late M. Perrotin (*Comptes Rendus*, vol. cxxxv. p. 881, 1902), who found from them—

$$\pi = 8''{\cdot}81,$$

but gave no indication of the probable error of his solution.

With his result the above solutions are in good agreement.

The probable errors are, however, disappointingly large, and remain persistently the same when the method of solution is varied. It is curious also that Solution VIIc., in which magnitude equation and star places are completely eliminated, agrees better with VIIb., in which the elimination is only partial, than with VIIa., in which it is nearly complete. This confirms the suggestion which we have noticed before, that neither star places nor magnitude equation are responsible for the comparative roughness of these "transit" observations.

§ 17. The series from the other observatories are not rich enough to bear division into seven groups for solution. We must be content to form normal equations and one solution for each observatory.

We have then—

Solution VIII.—Observatories "en bloc."

	$\Delta_0\alpha$.	P.	Wt.
Arcetri	$-0^s\cdot05655$	$+\cdot04275$	22
Besançon	$-\quad 2438$	$+\quad 484$	103
Christiania	$+\quad 825$	$+\quad 1500$	2
Nice	$-\quad 186$	$+\quad 189$	1071
Padova	$+\quad 256$	$+\quad 1251$	199
Pulkovo	$+\quad 1435$	$+\quad 826$	32
Teramo	$-\quad 761$	$+\quad 563$	22

whence $P = +\cdot00440 \pm 00166$

$\pi = 8''\cdot839 \pm ''\cdot015,$

—and we shall note that Nice in this solution gives exactly the same result as in VIIb. and VIIc.

§ 18. To complete the discussion of the transits we must divide them into fortnightly groups, as was done with the measures. Each observatory is given equal weight, as above.

Solution IX.—Fortnightly Groups.

Group.	$\Delta_0\alpha$.	P.	Wt.
0.	$+0^s\cdot00775$	$-\cdot01047$	45
I.	$-\quad 1879$	$-\quad 1746$	133
II.	$-\quad 488$	$-\quad 1269$	66
III.	$-\quad 1065$	$+\quad 807$	222
IV.	$-\quad 232$	$+\quad 1354$	223
V.	$-\quad 273$	$+\quad 893$	541
VI.	$+\quad 242$	$-\quad 189$	198

whence $P = +\cdot00395 \pm \cdot00259$

$\pi = 8''\cdot835 \pm ''\cdot022.$

Or, if we add together the normal equations for all seven groups and make one solution, we have—

$$\Delta_0 a = -0^s{\cdot}00270 \qquad P = +{\cdot}00411 \qquad \pi = 8''{\cdot}836.$$

§ 19. We have now to consider how to combine these solutions to form a definitive result. Collected they are—

Measures :—

Solution I.	14-day groups	$\pi = 8''{\cdot}803$	$\pm{\cdot}0034$	or IV. $8''{\cdot}804$ $\pm{\cdot}0035$
II.	,,	8·808		or V. 8·808
IIIa.	Koenigsberg	8·769	$\pm{\cdot}0165$	
IIIb.	Lick	8·845	$\pm{\cdot}0052$	
IIIc.	Teramo	8·796	$\pm{\cdot}0123$	
IIId.	Washington	8·798	$\pm{\cdot}0158$	
III.	Observatory groups	8·807	$\pm{\cdot}0072$	or VI. 8·808 $\pm{\cdot}0074$

Transits :—

VIIa.	Nice "Pairs"	$\pi = 8''{\cdot}809$	$\pm{\cdot}031$
VIIb.	,, All	8·816	$\pm{\cdot}031$
VIIc.	,, Morning—Evening	8·816	$\pm{\cdot}032$
VIII.	Observatory groups	8·839	$\pm{\cdot}015$
IX.	14-day groups	8·835	$\pm{\cdot}022$

In the Measures there is little difficulty, except for the abnormal value of π given by Lick with a small probable error. In judging this we are compelled to remember that a somewhat large number of the Lick series have had to be rejected for unexplained discordance, and that it is not certain that those remaining in the solution are altogether free from such disturbing cause.

In the Transits we have more difficulty. The addition to the strong Nice series of several not so strong has raised the deduced value of π considerably, though not by an amount out of proportion to the probable error of the Nice series.

In the Measures the fourteen-day group solution is much more internally accordant than the observatory group solution. In the Transits the reverse is the case.

We may perhaps take the Solutions I., III., VIII., and IX. as fairly representing the various interests.

If we combined them with weights inversely proportional to the squares of their probable errors we should give them weights 40 : 10 : 2 : 1 and should obtain

$$\pi = 8''{\cdot}8057.$$

If, on the other hand, recognising that I. and III. depend on the

same material, and VIII. and IX. on the same, we proceeded as follows:—

Mean of I. and III.	$8\cdot805 \pm \cdot0053$, say.
VIII. and IX.	$8\cdot837 \pm \cdot0185$, say.

Weights in proportion 12 : 1 give

$$\pi = 8''\cdot8075:$$

we should then perhaps err in giving too much importance to the transit series which raise the whole result so much.

After carefully weighing all the evidence of the above separate solutions, it seems to me that, as they stand, the most probable result to be derived from them is

$$\pi = 8''\cdot806 \pm \cdot004.$$

The assignment of the probable error must be a matter upon which opinions may differ, since the ordinary straightforward rules do not apply to a case like this.

§ 20. There remains one point for consideration. It has been pointed out in several places (see, for example, Greenwich Observations of Eros, p. lix) that if the parallax factors are computed for the mean of the times of individual settings, instead of for each separately, the deduced parallax is systematically small. In the case of the Greenwich photographs, if the series does not extend over more than 16^m, the error is about $-''\cdot0015$.

In this respect the micrometer series are very heterogeneous. Some have parallax factors computed for each set; others for each group. Some extend over very few minutes; others over 20^m or 30^m. It seems to me that there is no chance that the error introduced by this can exceed $-''\cdot002$ in the mean; and that this may very reasonably be set off against the probability, for other reasons given above, that our concluded result is a little high.

§ 21. It is a matter of satisfaction that the results for the micrometric and the photographic observations are identical. The photographic have considerably greater weight, as was expected; but the micrometric observations make a substantial contribution to the whole. Indeed, the probable error of the determination from the micrometer measures alone is less than that of the best previously existing determination of the Solar Parallax.

§ 22. I have to acknowledge with gratitude the services of Mr. S. E. Bowd who was employed in this work for four years. The cost of this additional assistance was defrayed by a series of grants from the Government Grant Fund of the Royal Society.

Cambridge Observatory:
1910 *June* 8.

Note on paper on certain families of Periodic Orbits.

By Sir George Darwin, K.C.B., F.R.S.

Mr. Hough has convinced me that I was wrong in the statement as to the mode of genesis of multiple figure-of-8 orbits on p. 140 of the *Monthly Notices* for December 1909 (vol. lxx.). It is asserted there that the range between the starting-points on the line of syzygies of a pair of multiple figures-of-8 is wider than that between the starting-points of the pair of single figures-of-8. This is wrong, for it is narrower. The sequence of origin of the successive multiple figures-of-8 as given by Mr. Hough in the *Acta Mathematica* (vol. xxiv., 1901) is correct, and the fourth paragraph on p. 140 should be corrected accordingly.

Mr. H. C. Plummer has remarked to me that the discussion of the differential equation in part i. is open to criticism, although the conclusions are right.

In reprinting this paper in vol. iv. of my *Collected Papers* I shall correct these oversights.

Observations of Halley's Comet made with the Altazimuth at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The following observations were obtained with the Altazimuth. Transits over the vertical and horizontal wires were observed both for the comet and for some neighbouring stars, from which the clock error and the azimuth error of the instrument were obtained.

Position of Instrument.	G.M.T. (uncorrected for Aberration).	Apparent R.A. of Comet (corrected for Parallax).	Apparent N.P.D. of Comet (corrected for Parallax).	Assumed log Δ.
	1910. d h m s	h m s	° ′ ″	
100°d	May 22 9 25 56·29	7 19 11·92	75 43 35·43	9·2549
90°d	23 9 16 34·63	7 57 12·17	78 13 14·19	9·3109
70°d	26 8 51 27·31	9 4 21·56	83 28 22·99	9·4795
,,	31 9 29 29·97	9 50 29·43	87 30 7·51	9·6860
,,	June 2 9 33 55·27	10 0 13·90	88 22 34·27	9·7691

The corrections applied for parallax are 48″·04, 41″·44, 26″·73, 17″·18, 14″·27 respectively, the approximate Zenith Distances being 79°42′, 74°53′, 66°43′, 71°42′, 72°46′.

Observer May 26, Mr. Crommelin; May 22, 23, 31, June 2, Mr. Furner.

Assumed Mean Places of Stars for 1910·0.

Star.	R.A.	N.P.D.	Days observed.
	h m s	° ′ ″	
λ Geminorum	7 12 55·291	73 17 47·83	May 23
β Canis Minoris	7 22 16·253	81 31 43·32	,, 23
κ Geminorum	7 39 0·990	65 23 9·00	,, 23
6 Cancri	7 57 59·560	61 57 9·66	,, 22
δ Cancri	8 39 34·352	71 30 51·90	,, 23
ι Cancri	8 41 15·270	60 54 37·18	,, 22
θ Hydræ	9 9 40·966	87 18 20·48	,, 26
α Lyncis	9 15 34·551	55 13 35·24	,, 22
ξ Leonis	9 27 5·787	78 18 4·23	,, 31
ο Leonis	9 36 20·925	79 41 52·28	,, 31
π Leonis	9 55 27·512	81 31 25·46	June 2
η Leonis	10 2 25·631	72 47 53·68	May 26
Regulus	10 3 34·851	77 35 33·17	,, 26, 31, June 2
γ^1 Leonis	10 15 0·782	69 42 10·41	June 2

Royal Observatory, Greenwich:
1910 *June* 10.

Halley's Comet and its Spectrum as observed at Kodaikánal.

By J. Evershed. (Plate 20.)

Halley's Comet was first observed by me as a morning star on April 18, at about $4^h\ 30^m$ a.m. I.S.T. It then appeared as a 2nd magnitude star, with a tail about 5 degrees in length. This early appearance of the comet as a conspicuous naked-eye object had not been anticipated by us, and our preparations for photographing the comet and its spectrum were by no means complete. We had, however, already available for direct pictures of the comet a portrait camera of 4 inches aperture and 35 inches equivalent focus attached to the North Dome equatorial, and this was immediately brought into use by Professor Michie Smith.

It seemed desirable to get photographs of the comet on both a larger and a smaller scale than that determined by the focal length of the portrait lens. For the larger scale I had available a $9\frac{1}{4}$-inch silver-on-glass parabolic mirror, and a 16-inch cœlostat lent us for another purpose by the Joint Eclipse Committee of the Royal and Royal Astronomical Societies.

A teakwood skeleton tube was built and mounted on an iron base as a horizontal telescope. A small brass box holding plates $3\frac{1}{4}$ in. $\times$ $3\frac{1}{4}$ in. was mounted near the open end of the telescope, and directly in the focus of the mirror. This box was very little larger than the plates, and obstructed about one-seventh of the

incident light. For guiding, a refracting telescope of 3 inches aperture and 36 inches focus was attached to the reflector, the cœlostat mirror being large enough to supply light to both instruments.

Guiding in declination was effected by moving the telescope in azimuth with a fine threaded screw, and in R.A. by means of an endless cord controlling the slow motion of the cœlostat.

The telescope was mounted east of the cœlostat, and directed towards the place of setting of the comet.

Owing to the small elongation of the comet west from the Sun, exposures much exceeding one hour were never possible, and most of the plates were not exposed longer than half an hour.

Excepting for certain irregularities in the driving of the cœlostat, the cause of which was not discovered, the whole apparatus worked extremely well, and good photographs of the comet were secured on 14 days between April 21 to May 17 inclusive. (Detailed particulars regarding these photographs, and the dates and times of exposure, will be found in a forthcoming bulletin of the Kodaikánal Observatory.)

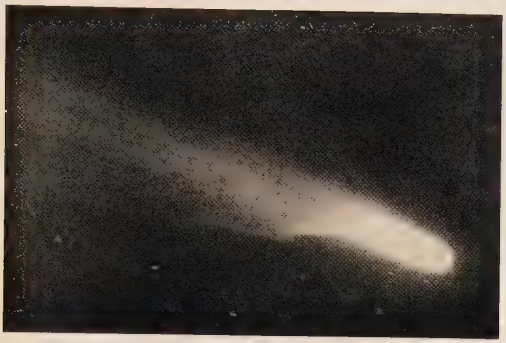
Owing to the small field of the reflector, the length of tail shown does not exceed 2 degrees in any of the plates. The most interesting plates are those obtained on April 22 and on May 13, reproduced on Plate 20, figs. 1 and 2. On the former date a strongly marked streamer is shown extending in a wavy line along the northern edge of the tail. It is very bright near the head, bends sharply outwards at 36′ from the nucleus, then follows the general direction of the tail in a wavy line for another 25′, when there is another sudden inflection or wave. It then continues in a nearly straight line to the edge of the plate, but inclined some 10 degrees to the general direction of the tail. Many more or less straight streamers are shown in the main tail, but these are interrupted by a patch of light extending diagonally across the tail from the first point of inflection in the northern streamer. A comparison of this photograph with others obtained elsewhere on the same date would probably give interesting information regarding the movement of matter in the tail.

The plate of May 13 is noteworthy for the well-defined edge of the coma on the northern side, and the large number of narrow, nearly straight streamers composing the tail.

The plate exposed on May 17 was somewhat fogged by the morning twilight. The head of the comet on that day rose so late that it was found necessary to continue the exposure, even in a rapidly brightening sky. The photograph shows the coma near the head about 40′ in width, with a central condensed patch containing the nucleus about 15′ in diameter.

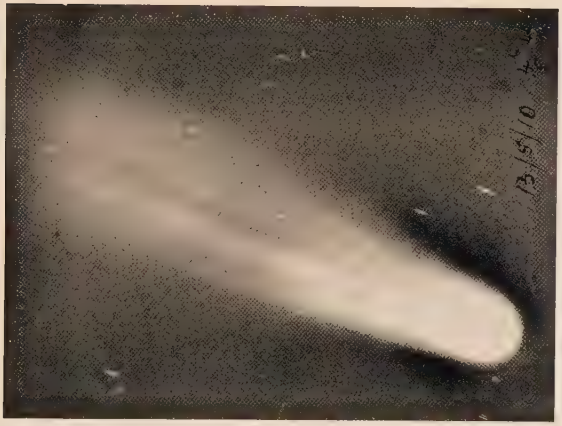
The comet on this date was distant from the Earth about 20 millions of miles, but on May 19, the day of transit across the Sun, the distance would be reduced to about 15 millions. If the actual dimensions of the comet remained the same, the condensed region of the comet would have covered two-thirds

1.



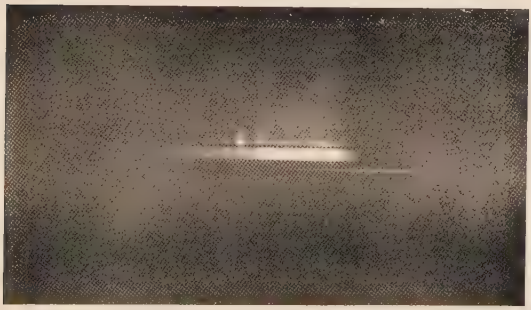
1910 APRIL 22, $4^h\ 44^m$ TO $5^h\ 17^m$ I.S.T.

2.



1910 MAY 13, $4^h\ 40^m$ TO $5^h\ 8^m$ I.S.T.

3.



SPECTRA OF COMET AND VENUS, 1910 MAY 1,
$4^h\ 40^m$ TO $5^h\ 10^m$ I.S.T.

HALLEY'S COMET.—J. EVERSHED.

of the Sun's disk during the transit, whilst the coma would have extended considerably beyond the Sun's limb on all sides. It was therefore realized, on seeing this photograph, that the transit would be, so to speak, a total eclipse of the Sun by the comet.

A large number of small scale photographs of the comet were secured with cameras ranging from 5 to 12 inches in focal length, and attached to the north and south equatorials: particulars of these will be found in the publication already referred to.

The Spectrum.

Two slit spectrographs were constructed specially for the comet. One of these was attached to the South Dome equatorial, and the other was designed for use with the 9¼-inch reflecting telescope. Both these instruments were found easy to manage and adjust; but although they gave brilliant images of the spectrum, I got no results of value from either of them. I attribute this want of success to the short exposure times available after the middle of May, as well as to poor conditions of seeing, the sky being generally more or less veiled by thin clouds. During the best presentation of the comet, early in May, an unexpected cyclone in the Bay of Bengal so disturbed the weather at Kodaikánal that no observations could be made.

Some fairly good spectrum photographs were obtained with a prismatic camera, specially designed for ultra-violet radiations, but these are also affected by the very moist atmospheric conditions that prevailed during May. The instrument had two 60° glass prisms of about 2 inches effective aperture, and a camera lens of 11½ inches focus. It was attached to the South Dome equatorial, the 6-inch telescope being used for guiding.

All the plates have, in addition to the comet spectrum, a comparison spectrum of either the star Altair or Venus, from which the wave-lengths of the comet lines can be determined. To get the spectrum of the star, or planet, properly aligned with that of the comet, the following procedure was adopted. One of the cross wires in the guiding telescope being set accurately parallel to the diurnal motion, a long exposure was made on the comet, keeping the head bisected at the centre of the field the whole time. As soon as it was judged to be too light to continue exposing on the comet, a dark cloth was gently placed over the prisms, and the telescope was unclamped and turned on the star or planet, which was then brought to the upper part of the field of view, bisected by the wire, and allowed to run along the wire by the diurnal motion. The prisms were then uncovered for perhaps one minute, or until the star had nearly reached the centre of the field, when the slide was shut. The star or planet was not allowed to impress the plate on the other side of the comet, because in that position it would have interfered with the tail images. The image of Venus with the camera lens of 11½

inches focus was small enough to give a very well-defined solar spectrum.

All the photographs taken of the spectrum are essentially similar (see fig. 3, Plate 20), and, so far as can be judged from a preliminary examination, there appears to have been no change even in the relative intensities of the different radiations throughout the period covered by the plates, that is, from April 21 to May 16. The spectrum consists of three distinct parts, viz.—

(1) A continuous spectrum due to the nucleus in which the Fraunhofer lines are faintly shown, such as Hβ, Hγ, 4325, 4310, 4270, 4227, Hδ, H, and K. These are displaced towards the violet compared with the same lines on the Venus spectrum by a measurable amount, notwithstanding the very small scale of the spectra.*

(2) A discontinuous spectrum of the gases surrounding the nucleus, but not extending into the tail.

(3) A series of monochromatic images of the tail.

Of the radiations in the head region of the comet the cyanogen emissions measured at $\lambda\lambda$ 3866 and 3890 are by far the strongest in the whole spectrum. They appear as distinct black spots in negatives which, from under-exposure, show nothing else in the spectrum whatever.

All the "head" lines which I have been able to detect on these plates are given in the following list of approximate wave-lengths. In this list a vertical line connecting two or more wave-lengths indicates a shading extending between, so that the separate lines can barely be distinguished. The micrometer thread was set at the points of maximum intensity.

Head Spectrum.

λ	Intensity.	Remarks.
3866	40	Cyanogen.
3890	50	
4015	10	
4041	2	Probably two lines.
4050	2	
4197	5?	Probably two lines.
4212	10	
4256	3	
4361	?	Swan spectrum (Fowler).
4371	8	

* A measurement of the displacement of the line 4227 on May 2 gave 1·08 Å, or a relative velocity of 77 km. per second, the comet approaching. On this date the comet was approaching the Earth at about 68 km. per second, but to this has to be added the velocity of recession of Venus. It is evident that the displacement is of the right order of magnitude, and that the alignment of the two spectra must have been practically perfect.

Head Spectrum.

λ		Intensity.	Remarks.
4631		?	Very faint.
4646		?	,,
4682		10	Swan 4685 + CO 4679 (Fowler).
4693		5	Swan spectrum.
4723		5	,, ,,
4739		5	,, ,,
4745	±	?	The Swan band seems to extend to 4745, but this may be partly a photographic effect.

The intensities given in column 2 are exceedingly uncertain: they are intended merely to give a very general idea of the spectrum. The wave-lengths must in most cases be regarded as uncertain by two or three units. A further set of measures has yet to be made, so that this list is provisional only, and may be slightly modified. The correction for the relative motion of Venus and the comet has been applied.

From the nature of these objective prism spectra the wave-lengths of the tail lines cannot be determined with accuracy. In the following list the positions are simply read off as carefully as possible from the spectrum of Venus, no correction being applied for the relative motion, since this scarcely exceeds one Ångström unit.

Tail Spectrum.

λ Comet.	Remarks.	λ CO (Fowler).	Intensity.
3585	Strong.	3594	5
369	Faint abroad, perhaps double.	3700	6
379	Faint, narrow.	3789	12
4014	Very strong, coincides approximately with line in head.	4011	14
413	Faint.	—	—
426	Strong.	4264	18
456	Strong.	4558	11
473	Faint.	4702	6

For comparison, I give the mean wave-lengths of the pairs of lines measured by Fowler in the low-pressure spectrum of carbon monoxide, and in the last column the sum of the intensities of each pair taken from his table.*

It will be seen from this comparison that all the lines measured by Fowler are represented in the comet spectrum, and the positions of the comet lines agree remarkably well with those of the CO spectrum, considering the very small scale of the comet spectra, and the difficulty in estimating the positions of the centres of the tail images.

* *Monthly Notices*, lxx. 488.

The relative intensities also are in fair agreement, excepting the line 3585, which is much too strong in the comet. The displacement of this line towards the violet compared with CO may be due to an erroneous estimate of its position by me, but I am inclined to believe that it points to a compound origin including the CO radiation.

The stronger tail images can be traced for about 3 degrees from the head on the plate of May 1st. On May 3rd they appear forked, although the direct photographs of the tail do not show this. The distance to which these monochromatic tail images can be traced on the plates seems to depend on the exposure time and on the condition of the sky during the exposure. I have little doubt that the discontinuous emission really extends to the extreme limits of the visible tail. But a change in the relative intensities of the different images might be anticipated in the outer parts of the tail, bearing in mind the interesting experiments of Professor Fowler on the spectrum of carbon monoxide.

The entire spectrum of Halley's Comet, so far as I have been able to observe it, seems to be identical with that of Comet 1907 *d* (Daniel) *; and although it may be said that these spectra of Halley's Comet show very little, if anything, that is new, yet it is of interest to have established, I think, on a firmer basis than hitherto, the close correspondence of the spectrum as a whole with the spectra studied by Professor Fowler under varying conditions of pressure, of carbon monoxide with traces of nitrogen.

Observations of the Tail of Halley's Comet before and after the day of Transit. By J. Evershed.

During the first two weeks in May, Halley's Comet presented a fine spectacle on clear mornings, and had already attracted a considerable amount of public attention and interest. On May 12 I measured the tail directly with a sector used for determining altitudes and found it to be 60 degrees in length.

On the mornings of May 17 and 18, which were quite clear at Kodaikánal, the tail was a magnificent object between 3 a.m. and 5 a.m. Passing over the star θ Aquilæ, it could be traced as far as the Milky Way, or more than 100 degrees from the head. The portion of the tail nearest to the Earth, and 90 degrees from the Sun, did not appear any wider on the 18th than on the previous day, although its actual distance must have decreased greatly during the interval.

On the 19th the sky was much obscured by hazy cloud, through which, nevertheless, the tail could be plainly seen. Its width was estimated to be $6\frac{1}{2}$ degrees at an altitude of about 20°.

* Cf. *Monthly Notices*, lxviii. 16.

No observation was made on the morning of the 20th on account of clouds, but on the evening of that day the head of the comet was seen after sunset, with a short tail (evidently much foreshortened) directed in the normal way opposite to the Sun.

On the 21st, when at sea off Colombo, I again saw the tail in the east at 4.30 a.m. It appeared no broader than on the 18th, but I think it was fainter. Passing centrally through the square of Pegasus, which was nearly filled with the faint light, the tail could be traced, as before, right up to the Milky Way. The star ϵ Pegasi was nearly in the centre of the band of light, and the star θ Aquilæ near its southern edge.

This was the last observation I was able to make before dawn. It seems very remarkable that the tail should have remained visible in the morning sky, as a narrow band of light, nearly two days after the head of the comet had passed to the other side of the Sun. A part of the tail on the 18th must have been rapidly approaching the Earth, and it ought to have widened out and disappeared as it enveloped the Earth.

At 4.30 a.m. on the 21st the head of the comet had passed far to the east of the Sun, and presumably was developing the tail seen the previous evening, directed away from the Sun towards the east. Yet the greater part of the tail remained on the west side of the Sun, apparently still at a great distance from the Earth, judging by its small width. If continuous with the head, it must have passed near the Sun's position, and might have been expected to appear as an abnormal tail on the sunward side of the comet.

No trace of a tail directed towards the Sun was seen by me on the evenings of May 20 or 21, although specially looked for, but the sky was very bright with the evening twilight and with moonlight.

The extraordinary persistence of the light in the eastern sky may perhaps be explained by supposing the tail to be strongly curved, and very broad in the direction of the comet's motion, although narrow and straight in the direction at right angles to this. If so, the passage of the Earth through the tail, if it occurred at all, must have been delayed one or two days, and probably occupied more time than a single day. There is some doubt whether the tail did actually touch the Earth, for observations of its position in the sky on May 11 and 15 show that its axis was inclined very considerably northward from the direction of the radius vector of the comet.

The Transit of Halley's Comet across the Sun.
By J. Evershed.

The following programme was arranged at the Kodaikánal Observatory for the observation of the transit.

(1) A careful scrutiny of the Sun's disk by direct observation with high powers, using the 6-inch Lerebour et Secretan refractor.

(2) A series of direct photographs to be taken with varying exposures and slow plates, on a scale of 8 inches to the Sun's diameter.

(3) A series of monochromatic photographs to be taken with the spectroheliograph, the camera slit being set on the head of the cyanogen fluting at λ 3883.

(4) A series of monochromatic photographs to be taken with the camera slit set on the line K, for comparison with the others.

(5) At the time of mid-transit some photographs were to be taken with the large grating spectrograph of the cyanogen bands at 3871 and 3883, observing at the same time the region of the blue "Swan" band.

Had the sky been clear, it was intended to begin the cyanogen photographs before ingress and to continue after egress, in the hope that with very long exposures the comet might appear as a bright object outside the Sun's limb. During the time of transit, exposures of about 30 seconds total duration would have sufficed to give good images of the disk, and the comet was expected to appear on these as a dark absorption marking, as is the case with many of the solar prominences.

I had great hopes of the success of these monochromatic plates, because of the very great intensity of the cyanogen radiations in the comet's head as revealed by the spectrum plates.

The time of ingress as communicated to us beforehand was $7^h\ 51^m \pm$ Indian standard time, and egress one hour later. Although clear skies are the rule in the early mornings at Kodaikánal, and had prevailed since January, the morning of May 19 was cloudy. At 8 a.m. there was a momentary gleam of sun, which enabled us to adjust instruments. At $8^h\ 30^m$ the clouds had thickened, and all hope of obtaining successful photographs was abandoned. But at about this time a cable message came through from Kiel which stated that ingress would not take place until $8^h\ 59^m$. This information, so opportunely received, saved the situation, as there occurred several moderately clear intervals between 9^h and 10^h, when it was possible to partly carry out the programme as regards items 1, 2, and 3. At no time was the Sun entirely free from cloud, and the intervals of moderate clearness were few. As a compensation, the definition, which is usually very poor after 9 a.m., remained good. No long-exposure plates before ingress or after egress were attempted on account of the thick clouds surrounding the Sun.

Results.—No trace of the comet can be seen on any of the direct photographs which were obtained, and Professor Michie Smith

could see nothing whatever of an unusual nature on the Sun's disk with the 6-inch telescope, although he states that the definition during the partially clear intervals was excellent.

Eight monochromatic photographs of the disk in the cyanogen radiation 3883 were obtained at the following times :—

No. of Plate.	I.S.T. h	m	Remarks.
794	8	59	Fair.
796	9	32	,,
797	9	35	Poor, much cloud.
798	9	38	Fair, good definition of details.
799	9	56	,, ,, ,,
800	9	59	Poor, much cloud.
801	10	02	Very poor and under-exposed.
802	10	19	Good.

All the plates are much streaked with cloud, but Nos. 796, 798, 799, and 802 are otherwise good, and show much minute detail all over the disk. If the times of ingress and egress transmitted to us from Kiel are not greatly in error, the comet should appear on the three plates Nos. 796, 798, and 799. A preliminary examination gives a negative result; and if the comet nucleus is shown at all, it must be too small or faint to be readily distinguished from the innumerable small markings, both dark and light, shown in all parts of the disk. On the other hand, the cyanogen part of the comet may be too large and diffuse to appear as a definite dark marking. The head of the comet emitting the cyanogen rays must have been larger than the Sun's disk, and it is probable that a more or less uniform dimming of the entire disk would escape notice, especially under such cloudy conditions.

Plate No. 802 is perhaps the best of the series, but it was exposed about 20 minutes after egress: this photograph does show a small dark spot, unlike a defect in the film, at 7′·6 north from the centre, in position angle 16° towards the east. The spot is about 7″ in diameter, and is quite opaque, but has ill-defined edges. A cloudy interval of 18 minutes preceded No. 802, and no more exposures were possible for over an hour afterwards. I had no opportunity, therefore, to ascertain whether this marking was moving at the same rate as the comet: it is certainly not shown on the earlier plates, and no trace of it can be seen on a direct photograph taken about two minutes earlier.

The Transit of Halley's Comet. By A. B. Chatwood.

Extract from a letter to the Astronomer Royal, dated Secunderabad, Deccan, 1910 May 19:—

Transit of Halley's Comet.

Very careful visual observation at this time failed to reveal the presence of the comet, and the immergence and emergence could not be detected. Observations were made with the 8-in Cooke 133-in. focal length triplet and single achromatic eyepiece 1·25-in. focal length and others. I cabled you as follows:—

Transit no trace comet seen
Chatwood.

—and trust this negative information will be useful.

Halley's Comet: Transit across the Sun, 1910 *May* 18.
By W. E. Cooke, M.A.

Two sets of ephemerides were available, one giving $14^h\ 22^m$ G.M.T. as the time of first contact, and the other, from *Popular Astronomy*, April 1910, p. 240, giving $15^h\ 50^m$. The weather has been unusually cloudy for some weeks, and the first possible chance of an observation for several days occurred last night, when a hasty setting gave the approximate position of

R.A. $6^h\ 56^m\ 10^s$ and Decl. $+15^\circ\ 28'$ on May 21, $22^h\ 5^m$ G.M.T.

(A 10^s-exposure photograph was also obtained, from which the exact position will be computed.)

This approximate place agrees so closely with the *Popular Astronomy* ephemeris, that we may conclude that the transit across the Sun's disc commenced at $15^h\ 50^m$ and finished at $16^h\ 48^m$. This was fortunate, because during the previous two hours, or from 14^h to 16^h, not a glimpse of the Sun was visible. After 16^h, however, several breaks occurred in the clouds, and clear views of the Sun were occasionally obtained. It was viewed by projection on the prepared surface of a Watson "new helioscope projection camera" attached to the 10-inch guiding telescope of the astrograph, and not only the spots but the granules were plainly visible. By giving a slow oscillating movement in R.A. to the telescope the surface markings were rendered still more clear. The results were negative, and not the slightest sign of a shadow or spot was perceptible.

Perth Observatory:
1910 *May* 23.

Halley's Comet, 1910: *Observations made in Jamaica.*

By Maxwell Hall.

From February 1 onwards the circular head and nucleus were seen through a small telescope at Halfway Tree near Kingston, but observations were not commenced until the disappearance of the Moon from the morning sky early in May.

May 6, 4 *a.m.* Chapelton. The Moon, three days before new, was rising; a small sketch was made showing the tail to be about 12° in length, and to make an angle of about 30° with the vertical to the right. Dawn occurred at 4.30 a.m.

May 8, 4 *a.m.* Chapelton. Another sketch was made showing the tail to be about 18° in length, and to make the same angle with the vertical as before.

May 14, 4 *a.m.* Halfway Tree. The tail extended to θ Pegasi, the central line being 1° south of that star, so that the end of the tail was at R.A. $22^h\ 6^m$ Decl. $+5°$, and its length was 46°. A sketch was made of the nucleus through the 3-inch telescope, showing it to be of a triangular form.

May 16, 4 *to* 4.30 *a.m.* Halfway Tree. The tail extended to the small group of stars 68, 69, 70, and 71 Aquilæ; it was a little south of the group. The tail was straight, about 3° broad, and of a silvery white colour; the head was brighter than a star of the 1st magnitude, but far below the brightness of Venus. The central line of the tail passed about 1° south of θ Pegasi as on the 14th.

It was deduced that the end of the tail was at R.A. $20^h\ 30^m$ Decl. $-4°$, and that its length was $80\frac{1}{2}°$.

May 17, 3 *a.m.* Chapelton. The tail extended to the same group nearly, but the middle of the tail was at the middle of the group. The upper edge of the tail pointed to θ Aquilæ. At θ Pegasi its width was about half the distance between that star and α Aquarii, or $3\frac{1}{2}°$.

It was deduced that the end of the tail was at R.A. $20^h\ 35^m$ Decl. $-2\frac{1}{2}°$, and that its length was 87°.

The head could not be seen from the place of observation, but it was seen at another place in Chapelton from 4.20 a.m., when it rose, until 4.35 a.m., when dawn overpowered it.

May 18, 4 *to* 4.20 *a.m.* Chapelton, at the hospital grounds for better view. The central line of the tail passed $\frac{1}{2}°$ south of γ Pegasi and over θ Pegasi. The northern edge touched θ Aquilæ, and it reached nearly to the Milky Way. Its breadth at γ Pegasi was about 5°, and at θ Pegasi 4°.

It was deduced that the end of the tail was at R.A. $19^h\ 30^m$ Decl. $\div 4°$, and that its length was 113°.

Dawn occurred at 4.25 a.m. As the comet's head would not rise until 4.53 a.m., and as daylight interfered at 5.5 a.m., it was not thought remarkable that the head was not seen, especially as there were some light clouds over the eastern horizon.

May 19, 3 *to* 3.20 *a.m.* Chapelton. As the tail was supposed

to have swung round to the western sky during the night, it was surprising to see the tail still in the eastern sky. It was broader and dimmer than before, and somewhat resembled the Zodiacal Light when well seen.

The following observations were made:—The centre of the band passed over ζ Pegasi and θ Aquilæ, and its end was lost in the Milky Way. The centre of the band passed between ϵ and θ Pegasi, the edge nearly touching ϵ, and enclosing θ, so that the centre was a little south, and so that its breadth between these stars was 6°.

After 3.20 a.m. it became cloudy, and it was a cloudy evening.

May 20, 3.30 *to* 4.30 *a.m.* Chapelton, at the hospital grounds. The southern edge of the band was clear of γ Pegasi; the northern edge was very ill-defined and lay about 1° beyond α Andromedæ. The southern edge touched ζ Pegasi. The band was central between ϵ Pegasi and α Equulei; also between θ and η Aquilæ; its end was lost in the Milky Way.

Between ϵ Pegasi and α Equulei its breadth was $\frac{3}{4}$ the distance between these stars, or 7°; but between γ Pegasi and α Andromedæ it was as much as 15°.

The southern edge was very well defined, and there was a dark space between it and the Zodiacal Light, which was seen faintly to the right.

May 20, 7.30 *p.m.* Montego Bay. A sketch was made of the comet in the west and its new fan-shaped tail, which stretched away from the Sun. It was about 13° in length, and its greatest transverse width was 6°. The head was brighter than γ Geminorum, and of about the 2nd. magnitude.

There was no appearance of any tail below, or of any connection with its former tail. There was moonlight, and there were light clouds to the west; but the observations were reliable as far as they went.

May 21, 3.40 *a.m.* Montego Bay. Moon set. Band very faint. Its southern edge was 2° north of γ Pegasi, and touched α and ϵ Pegasi. Its northern edge was at α Andromedæ. Its width at α Pegasi was from that star to 1° south of μ Pegasi or 9°.

The Zodiacal Light was pretty distinct, and there was a dark band in the sky between the two.

4 *a.m.* Very clear. The cometary band was very strong on the N.E. horizon and very broad; it followed the line of the stars α, β, γ Andromedæ, and its width was from γ Andromedæ to α Arietis, or 19°.

4.10 *a.m.* There was a strong light to the N.N.E. under Cassiopeia.

4.15 *a.m.* The band over the N.E. horizon looked exactly like a fine display of the Zodiacal Light; it was of a pearly white colour.

4.22 *a.m.* Dawn, and the whole band rapidly disappeared.

May 21, 7.10 *to* 7.30 *p.m.* Kempshot Observatory. The tail had increased to 28½°, and had lost most of its fan-shaped appearance. Its extremity was at R.A. $8^h\ 30^m$ Decl. +12°. The

nucleus was as bright as γ Geminorum. The head was viewed under different powers, but there was no connection whatever with the former tail.

May 22, 4.18 a.m. Kempshot Observatory. The Moon had just set, but dawn had commenced. A glow was seen above the N.E. horizon, but it was mixed up with the Zodiacal Light on the right and the Milky Way on the left, so that its boundaries could not be made out.

Moonlight prevented any further morning observations of this fading cometary band.

7.30 *p.m.* The fan-shaped appearance of the tail had all gone; the observed length was about 34°, and this was the maximum for the new tail seen in the west. With a power of 120, the nucleus was only 4″·4 in diameter; and as log Δ was 9·2654, this gave a diameter of only 365 miles.

The subsequent observations made were of no particular interest; on the 30th. the length of the tail was 30°, and then it rapidly diminished.

Deductions were made from these observations, and notices were sent to the local press from time to time; but a more complete study than was then possible is now required.

Jamaica: 1910 *June* 4.

Observations of Halley's Comet made on board s.s. "Mobile."

By Captain P. Bisson.

(*Communicated by Capt. Campbell Hepworth.*)

On May 7, at about $3^h\ 30^m$ a.m. mean time at ship, in approximate position lat. 39° 22′ N., long. 59° 40′ W.

Observed angular length of comet's tail 7° 12′.

The night was dark and the comet showed up plainly. The head appeared about the brightness of a second magnitude star. Did not observe any split in the tail.

Meteorological Office, London, S.W.:
1910 *June* 6.

Observations of Halley's Comet made on board s.s. "Romanic."
By Captain H. P. David and H. N. M'Gill, Fourth Officer.

(*Communicated by Capt. Campbell Hepworth.*)

May 18, 1910. Position 40° 51′ N., 43° 34′ W.

At $2^h 45^m$ a.m. observed luminous tail of Halley's Comet, rising from a point 5° above horizon; on true bearing of N. 80° E., and extending upwards into sky at an angle of 35°.

Tail appeared to preserve an uniform width of 4°, and passed through lower corner of the square of Pegasus, the star γ Pegasi appearing plainly through it.

It extended nearly to α Aquilæ, where it became invisible to the naked eye.

Cumulus clouds obscured the horizon to an altitude of 6°, which may account for not seeing the comet itself.

The planet Venus rose at $3^h 30^m$ a.m., ship's time, appearing exceptionally brilliant, though daylight was rapidly coming in.

At $3^h 45^m$ a.m., when daylight had fully broken, the tail became invisible. It was seen at its best at $3^h 15^m$ a.m., when the Moon had set.

Sunday, May 22. Position 36° 25′ N., 9° 40′ W.

Ship's time $8^h 24^m$ p.m. = 9.10 p.m. G.M.T.

Observed Halley's Comet bearing N. 85° W. (true), altitude 18°.

Angular distance with α Canis Minoris 9° 46′.
" " " β Geminorum 14° 45′.

Comet, as compared with bright stars near, appeared about the same size as Jupiter, but with little luminosity, and of a distinctly yellowish tinge.

There was little or no tail to be seen, probably owing to the Moon being at the full and shining brightly.

Meteorological Office, London, S. W.:
1910 June 6.

Observations of Halley's Comet made on board s.s. "Majestic."

By J. Jenkins, Fourth Officer.

(*Communicated by Capt. Campbell Hepworth.*)

During the last voyage of the above ship from New York to Plymouth a good opportunity occurred for observing Halley's Comet. It was on the evening of May 28, and the night was exceptionally clear and cloudless.

The comet's head was directly under α Leonis, and I should say about half as bright as that star in the centre of the nucleus. The tail at the end nearest the head would be about the same brightness as the bright parts of the Milky Way on a clear night. It followed a straight line from the head to α Virginis, and was visible by the naked eye for about half the angular distance from the head to that star, this making the visible part of the tail about 30° in length. The width of the tail at this part would be about 2° and at the head about 8′. These widths are very rough approximations, as it was only by noticing with the sextant the angular distance between two stars which appeared to correspond with the width of the tail that they were obtained. The luminosity of the tail faded gradually and evenly as its distance from the head increased. The head, through the night telescope, appeared like a ball of white fluff, about twice the size of Jupiter as compared with that planet at the time, and at no time was there any sharp definition of outline of the head or tail. The brightness of the head and tail varied at times, something after the fashion of the Northern Lights.

At $11^h\ 55^m$ p.m. G.M.T. on May 28, the ship by stellar observations being in lat. 43° 12′ N., long. 42° 5′ W., the comet's head bore S. 70° W. true; its angular distance as measured by sextant from α Leonis was 11° 35′, from α Virginis 59° 29′, from α Hydræ 12° 43′. At $1^h\ 32^m$ a.m. G.M.T. on May 29, ship's position being lat. 43° 25′ N., long. 41° 26′ W., the comet's head bore S. 89° W. true; its angular distance from α Virginis was 59° 8′, from α Leonis 11° 32′, from α Boötis 69° 56′, from Jupiter 42° 23′.

At $2^h\ 10^m$ a.m. G.M.T. on May 29, ship's position being lat. 43° 30′ N., long. 41° 13′ W., the comet's head set bearing N. 85° W. true. Height of eye 47 feet. The comet's head at this time was so faint, that the time of setting and bearing were obtained by angular distance from α Leonis and a previous comparison of bearing with that star, both the angular distance and the bearings altering so little in comparison that they served to help to get a very good approximation of the time of setting, and also the bearing. The comet appeared at its brightest at the time the first set of observations were obtained.

Meteorological Office, London, S.W.:
1910 *June* 6.

Sextant Observations of Halley's Comet made on board s.s. "Clan Urquhart." By G. A. Neill, Chief Officer.

(Communicated by Capt. Campbell Hepworth.)

April 27, about 4^h 15^m a.m. A.T.S., lat. 5° 40′ N., long. 81° 19′ E.
G.M.T. 26, 10^h 56^m 16^s. α Aquilæ 60° 15′ 30″ from comet.
,, 26, 11^h 00^m 6^s. Venus 14° 9′ ,, ,,

April 27, about 4^h 45^m a.m. A.T.S., lat. 5° 40′ N., long. 81° 12′ 15″ E.
G.M.T. 26, 11^h 31^m 36^s. Venus 14° 6′ 30″ from comet.
,, 26, 11^h 33^m 26^s. α Pegasi 14° 6′ 30″ ,, ,,

May 1, about 4^h 20^m a.m. A.T.S., lat. 7° 31′ N., long. 77° 25′ 30″ E.
G.M.T. 30, 11^h 21^m 0^s. Venus 11° 55′ 15″ from comet.
,, 30, 11^h 25^m 25^s. α Pegasi 14° 26′ ,, ,,

May 1, about 4^h 40^m a.m. A.T.S., lat. 7° 32′ N., long. 77° 22′ E.
G.M.T. 30, 11^h 33^m 30^s. α Pegasi 14° 25′ from comet.
,, 30, 11^h 37^m 0^s. Venus 11° 55′ ,, ,,
,, 30, 11^h 41^m 40^s. α Andromedæ 20° 40′ 15″ from comet.

May 3, about 4^h 45^m a.m. A.T.S., lat. 8° 48′ 30″ N., long. 69° 55′ 30″ E.
G.M.T. 2, 12^h 7^m 8^s. α Andromedæ 20° 22′ 30″ from comet.
,, 2, 12^h 9^m 28^s. α Pegasi 14° 53′ 15″ ,, ,,

May 4, about 4^h 40^m a.m. A.T.S., lat. 9° 30′ N., long. 66° 2′ 30″ E.
G.M.T. 3, 12^h 12^m 48^s. α Andromedæ 20° 10′ 30″ from comet.
,, 3, 12^h 15^m 4^s. α Pegasi 15° 12′ ,, ,,

May 5, about 4^h 50^m a.m. A.T.S., lat. 10° 9′ 45″ N., long. 62° 25′ 15″ E.
G.M.T. 4, 12^h 37^m 58^s. α Pegasi 15° 38′ 30″ from comet.
,, 4, 12^h 40^m 6^s. α Andromedæ 19° 57′ 30″ ,, ,,

May 6, about 5^h 0^m a.m., lat. 10° 48″ N., long. 58° 43′ E.
G.M.T. 5, 12^h 52^m 33^s. α Andromedæ 19° 41′ 30″ from comet.
,, 5, 12^h 54^m 34^s. α Pegasi 16° 8′ 30″ ,, ,,
,, 5, 12^h 57^m 36^s. α Piscis Australis 42° 26′ ,, ,,

May 7, about 4^h 40^m A.T.S., lat. 11° 23′ 30″ N., long. 55^h 7′ 30″ E.
G.M.T. 6, 12^h 54^m 41^s. α Andromedæ 19° 28′ 30″ from comet.
,, 6, 12^h 57^m 11^s. α Pegasi 16° 48′ ,, ,,
,, 6, 12^h 59^m 18^s. α Piscis Australis 43° 3′ ,, ,,

May 8, about 5 $^{h}5^{m}$ a.m. A.T.S., lat. 12° 15′ N., long. 51° 10′ E.
G.M.T. 7, $13^{h}\ 26^{m}\ 46^{s}$. α Andromedæ 19° 11′ 30″ from comet.
,, 7, $13^{h}\ 30^{m}\ 5^{s}$. α Pegasi 17° 32′ ,, ,,
,, 7, $13^{h}\ 32^{m}\ 30^{s}$. α Piscis Australis 43° 39′ 30″ from comet.

May 9, about $5^{h}\ 0^{m}$ a.m. A.T.S., lat. 12° 32′ N., long. 47° 21′ 30″ E.
G.M.T. 8, $13^{h}\ 28^{m}\ 58^{s}$. α Andromedæ 18° 56′ from comet.
,, 8, $13^{h}\ 30^{m}\ 57^{s}$. α Pegasi 18° 28′ 45″ ,, ,,
,, 8, $13^{h}\ 33^{m}\ 35^{s}$. α Piscis Australis 44° 25′ 30″ from comet.

May 11, about $4^{h}\ 40^{m}$ a.m. A.T.S., lat. 15° 44′ 30″ N., long. 41° 32′ 30″ E.
G.M.T. 10, $13^{h}\ 51^{m}\ 50^{s}$. α Andromedæ 18° 32′ from comet.
,, 10, $13^{h}\ 54^{m}\ 55^{s}$. α Pegasi 21° 9′ ,, ,,
,, 10, $13^{h}\ 58^{m}\ 20^{s}$. α Piscis Australis 46° 39′ 45″ from comet.

May 12, about $4^{h}\ 42^{m}$ A.T.S., lat. 18° 58′ N., long. 39° 33′ 30″ E.
G.M.T. 11, $13^{h}\ 52^{m}\ 26^{s}$. α Andromedæ 18° 37′ 30″ from comet.
,, 11, $13^{h}\ 54^{m}\ 15^{s}$. α Pegasi 22° 59′ ,, ,,
,, 11, $13^{h}\ 56^{m}\ 56^{s}$. α Piscis Australis 48° 8′ ,, ,,

May 13, about $4^{h}\ 33^{m}$ a.m. A.T.S., lat. 22° 9′ 45″ N., long. 37° 36′ 15″ E.
G.M.T. 12, $13^{h}\ 57^{m}\ 4^{s}$. α Andromedæ 18° 59′ from comet.
,, 12, $13^{h}\ 59^{m}\ 13^{s}$. α Pegasi 25° 22′ 30″ ,, ,,
,, 12, $14^{h}\ 1^{m}\ 28^{s}$. α Piscis Australis 50° 6′ 30″ ,, ,,

Meteorological Office, London, S. W.:
1910 *June* 7.

Observations of Halley's Comet made on board s.s. "Miami."
By W. G. Preece, Second Officer.

(*Communicated by Capt. Campbell Hepworth.*)

On April 29, at about 7 o'clock a.m. G.M. time, in latitude 26° 56′ N., long. 52° 50′ W., I observed a very bright comet, rising in close proximity to Venus and γ Pegasi. From that date onwards it became brighter and the tail longer each day, until on May 16 its tail reached from the horizon to the zenith. It seemed to be travelling towards the north and west. After May 16 we were unable to see either the comet itself or the tail on account of daylight breaking so early.

Meteorological Office, London, S.W.:
1910 *June* 6.

Sextant Observations of Halley's Comet.

By Capt. W. L. Rosseter.

(*Communicated by Capt. Campbell Hepworth.*)

Star distances from Halley's Comet taken at Lyminge, Kent, May 26, 1910.

Time.	Star or Planet.	Distance.
$9^h\ 38^m$ p.m.	α Boötis	75° 20′
	α Ursæ Majoris	59° 30′
Mean $9^h\ 48^m$	Jupiter	49° 0′
	α Lyræ	122° 56′
$9^h\ 59^m$	α Leonis	15° 38′

Meteorological Office, London, S.W.:
1910 *June* 6.

Sodium in Comets' Tails. *Note on paper by Professor A. Fowler, Monthly Notices*, lxx. p. 494.

By T. W. Backhouse.

In reading this paper the question arises whether Professor Fowler has overlooked the case of Comet Wells 1882 *a*. I have only the opportunity of referring to my own observations, while probably those of other observers were much more complete; but I give extracts from mine.

1882 June 7, $14^h\ 25^m$ G.M.T.

With Browning's "miniature spectroscope" on $4\frac{1}{4}$-inch refractor, in addition to the continuous spectrum of the nucleus, the bright sodium line is visible not only in the nucleus, but also to a distance of about 6′ from it.

$15^h\ 0^m$. The sodium line just fits into the D solar line * in the spectrum of twilight and hides it. No other line visible in the comet's spectrum.

On this date and the preceding the comet was yellow. On the 4th. I had called it yellow or straw-coloured; on the 1st. pale straw-colour, or pale dull yellow That was the first date on which I saw the sodium in the spectrum, and two of the carbon bands still remained faintly visible, and other bands only suspected. As the whole comet appeared yellow to the eye, the impression is naturally given that sodium existed throughout. Its length on the 1st. was 2°, on the 6th. about 20′, and on the 7th. 50′.

I did not observe the spectrum of Comet 1910 *a*, but on Jan. 22 I noticed the whole comet, which was visible to a length of 10°, was deep yellow, and I was forcibly reminded of Comet Wells; so that I obtained the impression that the light of the whole was probably likewise due to sodium.

* This is a single line with this spectroscope.

West Hendon House,
Sunderland: 1910 *May* 28.

Remarks by Professor A. Fowler, F.R.S.

In the part of my paper to which Mr. Backhouse refers, I only dealt with those comets which had been "spectroscopically observed at any considerable distance from the head," and purposely omitted Comet Wells because the sodium lines had only been definitely traced to a distance of 6′ or 7′ from the nucleus.* I do not deny the possibility that the yellow colour of the tail of this and certain other comets may have been due to sodium, but in the absence of spectroscopic measurements, and in view of the difficulty of conceiving the existence of sodium vapour at great distances from the nucleus, the yellow band of the "high-pressure" carbonic oxide spectrum was suggested as a possible alternative explanation of the yellow image of the tail observed through a prism in the case of the Great Comet of 1882. The mere presence in the tail of dust particles containing sodium compounds would probably not account for the appearance of the sodium lines, as Liveing and Dewar have shown that fine particles suspended in a gas through which an electric discharge is passing do not exhibit their characteristic spectra.† If the occasional presence of sodium lines in the spectra of comets' tails should be established, an explanation may perhaps be found in the supposition that the sodium light of the nucleus is reflected by the fine particles of which the tail is partly composed.

Notes on Photographs of Nebulæ made with the 60-inch Reflector of the Mount Wilson Observatory, by Professor G. W. Ritchey, Assoc. R.A.S. (Extracts from two letters sent by Professor Ritchey to accompany enlargements of Nebulæ presented to the Society.)

I.

I am sending you to-day by express for the R.A.S. three glass positives (14 × 17 inch) of spiral nebulæ which I have recently photographed with the 60-inch reflector. Messier 51 and Messier 81 are not particularly good; the negatives were both made in February, under moderately good winter conditions; I send them, however, because Messier 51 is of great general interest, and Messier 81 illustrates well the tendency of the branches of these spirals to break up into soft star-like condensations which I call nebulous stars. Messier 101 was photographed in March, under much better atmospheric conditions than the other two, and this photograph shows fairly well what the 60-inch will do under *good average* conditions, and with the photographic plates which I am using, as the best now available for my purpose, namely, Seed 23.

* Copeland and Lohse, *Copernicus*, vol. ii. p. 232.
† *Proc. Roy. Soc.*, vol. xlviii. p. 437 (1890).

My experience last summer showed that a new photographic attachment or plate-carrier for the 60-inch was desirable, which should embody the following improvements as compared with the $6\frac{1}{2} \times 8\frac{1}{2}$ inch double slide plate-carrier which I used during the summer of 1909. First, the guiding eyepiece should have twice the magnifying power of the former one; the new one is about 800 diameters. Second, a second guiding eyepiece and guide star are used (the two being on opposite sides of the centre of the field); this is to allow correction for any slight rotation of the field. Third, the photographic plate is very small, only $3\frac{1}{2}$ inches square, so as to allow the guiding eyepiece and guide star to be as near the centre of the field as possible. Fourth, the new plate-carrier allows the small plate-holder to be *taken off* bodily and replaced as frequently as is desired during the exposure, for the purpose of allowing access to the focal plane for *refocussing every half-hour*. This is done with a sharp knife-edge such as I use in optical testing. When atmospheric conditions are not below 5 on a scale of 10, I can focus by this method to $\frac{1}{1000}$ inch with the 60-inch. The canvas sun-protection on the dome and the constant-temperature canopy which covers the telescope during the day prevent large focal changes at night. Refocussing every half-hour or 40 minutes is sufficient to keep in the true focal plane to within $\frac{1}{1000}$ to $\frac{1\frac{1}{2}}{1000}$ inch. With this new plate-carrier and focussing method the photograph of Messier 101 was secured on March 10 and 11; the exposure time was $7\frac{1}{2}$ hours with Seed 23 plate and 54 inches aperture of mirror. The smallest star-images on this negative are 1·6 seconds of arc in diameter. In a negative of the globular star-cluster Messier 3 which I made on April 9 with $3\frac{1}{2}$ hour exposure the smallest star-images (tens of thousands of them) are only 1·15 seconds of arc in diameter. I hope to send you positives of this and of Messier 13 next month.

It seems to me that the 60-inch photographs throw much new light on the subject of the spiral nebulæ. They show, in the case of all the spirals which I have photographed, that the branches are apparently composed both of smooth nebulous material and also of soft star-like condensations or nebulous stars, as if the spiral nebulæ were actually condensing into stars. In Messier 33 Trianguli I have counted over 2400 of these nebulous stars; in Messier 101 Ursæ Majoris, which I send, I have counted over 1000; in Messier 81 Ursæ Majoris approximately 400; in Messier 51 Canum Venaticorum, about 250; in Messier 63 Canum Venaticorum, about 200.

Messier 64 Comæ Berenicis is unlike all of those above named in that the 40 or 50 nebulous stars shown in it are near the centre of the nebula, while the outer branches are apparently smooth, without condensations. In Messier 33 and Messier 101 the nebulous stars are frequently massed in great branches. The Great Andromeda Nebula is more like Messier 81; in both, the central parts apparently consist of smooth material with complicated systems of dark rifts, while the outer branches contain great numbers of nebulous stars.

It appears to me that these photographs strongly oppose, if they do not effectually preclude, the theory that has been again advocated of late, that the spiral nebulæ are distant systems of stars like our Milky Way.

In all of my recent work with the 60-inch I have used Seed 23 plates on account of their fineness of grain. These plates are about half as rapid as Seed 27 and Cramer "Crown," and are about one-fourth or one-fifth as rapid as Lumière Sigma and Violette.

I have decided at the last moment to send also some smaller positives from negatives which I made last fall with the older plate-carrier. One is of the central parts of the Great Andromeda Nebula, showing the nucleus and the dark rifts immediately surrounding it; this shows the spiral structure extending practically to the nucleus. One is the Crab Nebula, showing the remarkable filamentous structure and the antenna-like branches.

One is of the Ring Nebula in Lyra, showing this to be composed of at least three irregular rings, apparently interwoven.

The photograph of the Ring Nebula illustrates well the enormous importance of very fine-grained plates in this work. This nebula is bright enough (in ultra-violet light) to give a good negative on the fine-grained very slow Seed "Process" plate with 30-minute exposure. The result is that extremely fine details are shown, allowing a magnification of the negative of 12 or 15 diameters without objectionable granulation, while Seed 23 plates allow about 8 diameters, and Seed 27 or Cramer "Crown" about 4 diameters. Lumière Sigma and Violette allow only 2 or 3 diameter magnification. This with the same quality of "seeing" and the same care in guiding.

Cramer "Crown" and Seed 27 plates are about 40 times more rapid than wet plates. Seed 23 plates are about 20 times more rapid than wet plates. Seed "Process" plates are about 3 to 6 times more rapid than wet plates. These last plates vary greatly in speed, and are relatively highly sensitive to ultra-violet light.

The data in regard to each of the photographs sent are given on the label of the glass positive—exposure time, enlargement, scale, date, plate, etc.

None of the original negatives have been reduced or retouched in any way. The positives of Messier 101 and the Ring Nebula were enlarged directly from the negatives without any "shading" (to build up strength in the positive in any part). But in the case of the Andromeda Nebula, Messier 1, Messier 51, and Messier 81, the central regions (which are comparatively very dense in the negatives) were given more exposure in making the positives, in order to prevent a too thin and glassy centre.

Mount Wilson Solar Observatory:
1910 *April* 22.

II.

I send a large positive of the globular cluster Messier 3, which affords the best example thus far secured of the powers of the 60-inch reflector with its new plate-carrier. As I wrote you last month, this plate-carrier allows accurate refocussing to be done every half-hour, or oftener if desired, and allows corrections for any slight rotation of the field during long exposures. Both of these are absolutely necessary for the finest results with an instrument so large and sensitive as the 60-inch. With these refinements, indefinitely long exposures can be continued on successive nights with the assurance that no injury or elongation of the star-images can occur, and that the full effect of the prolonged exposure is secured. One of the 8×10 positives shows the new plate-carrier.

The smaller star-images on the negative of Messier 3 are $1''{\cdot}15$ in diameter. The photograph was exposed $3\frac{1}{2}$ hours, with 54 inches aperture of the mirror. The plate used was Seed 23; it is only $3\frac{1}{2}$ inches square, and the clear field photographed is about $35'$ square. The field shown in the positive is approximately $28' \times 23'$.

In making the positive enlargement of this structure the dense centre was exposed twice as long as the outer parts (by means of a circular opening in a paper screen).

The photograph of the Great Nebula in Andromeda includes approximately $20' \times 25'$. It was made with the old plate-carrier, hence the exposure was necessarily short (2 hours), to avoid elongation of the star-images. The star-like nucleus is well shown. The most striking features, to my mind, are the complicated structure and curdling flocculent character of the dark rifts, especially to the right of the centre; and particularly the remarkable resemblance of these rifts to many of the dark rifts which Professor Barnard has photographed in the Milky Way. You undoubtedly have copies of Professor Barnard's photographs, and if you will refer in particular to the one showing the large curved rift just north-west of Theta Ophiuchi you will notice the astonishing resemblance to those in the Andromeda Nebula. The similarity is so complete and striking that the question is immediately raised whether the nature of the two is not identical; in other words, if we could view the Milky Way from the proper position and distance in space, would it not closely resemble the Andromeda Nebula? Two facts oppose this view: first, the Andromeda Nebula has a strongly condensed centre and nucleus; second, the Andromeda Nebula has great streams of nebulous stars in its outer convolutions.

(In making the positive enlargement of this Nebula no reducing whatever was done to the negative, but the central region was given a much longer exposure than the outer parts, by means of a series of paper screens with properly shaped openings.)

The positive of the Orion Nebula shows a great amount of new and interesting detail. In the original negative the six principal

stars of the Trapezium are well shown. This negative was so dense in the brilliant region around the Trapezium that it was slightly reduced locally in order to yield such a positive as the one I send.

The small positive of the Owl Nebula is from a negative taken on a poor night; hence the rather large star-images. This negative is most interesting because of the great number of small nebulæ, about 100, many of them spiral, shown in the field 35′ square surrounding the nebula. The exposure was 4 hours; the number of small nebulæ is approximately equal to the number of stars shown.

1910 *May* 21.

[The photographs will shortly appear in the Society's series of Reproductions of Celestial Photographs.]

The Long Period Variable V Cassiopeiæ (*Ch.* 8324) *in* 1909–10.

By A. N. Brown, M.A. (Plate 21.)

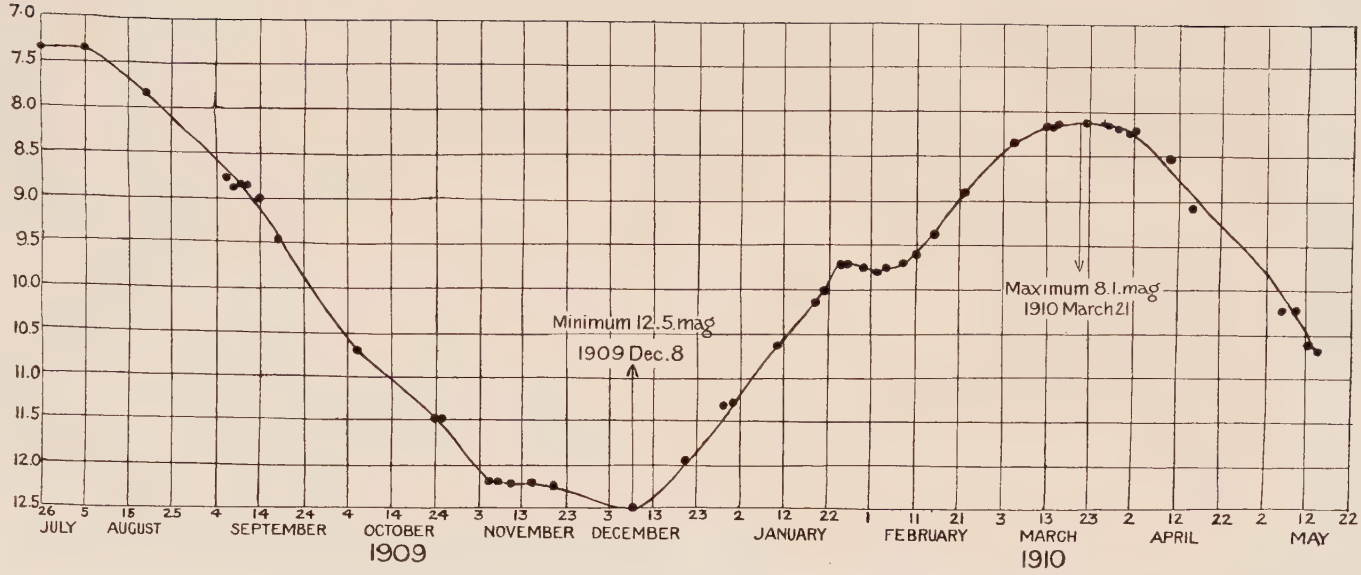
I have had this star upon my working list since the beginning of 1909, but was unable to observe it at frequent intervals until the end of July. The first six, therefore, of the fifty-five observations which follow are not used in drawing the curve herewith produced. A minimum of 12·5 mag. is shown as having occurred on 1909 December 8, and a maximum of 8·1 mag. on 1910 March 21. On two occasions there appears to have been a halt or pause in the changing light of the Variable, the first before the minimum, five observations made between 1909 November 5 and 20 indicating a difference of only ·04 mag.; the second, which is even more clearly marked, preceded the maximum. Indeed from 1910 January 25 to February 2 the light appeared to diminish by about ·1 mag.

The observations are arranged upon exactly the same plan as that adopted in my recent paper on RT Cygni, published in *Monthly Notices*, vol. lxx. No. 3. Every remark made there as regards the contents of each column, the abbreviations employed, and the method of recording the comparisons applies here also, except that in the observations below the Harvard magnitudes have been employed throughout, these magnitudes being obtained from the column headed HP. in Series VI. of Hagen's *Atlas Stell. Var.*

[Table.

The Observations.

Date.	Julian date.	Instr.	Class.	Comparisons.	Ded. mag.
1909.					
Jan. 27	8334	t. 75	I	15+2	9·3
Feb. 19	8357	T. 120	,,	32−4·5, 43+1·5	10·8
21	8359	,,	,,	43−2, 51+1	11·1
May 5	8432	T. 150	...	∠51	∠11·2
8	8435	,,	I	69−2, 73+1	12·2
20	8447	T. 120	,,	=51	11·2
July 26	8514	t. 30	,,	3−10·5, 4+3·5	7·4
Aug. 5	8524	t. 16	,,	3−10·5, 4+3·5	7·4
19	8538	,,	,,	4−1·5, 5+4·5	7·9
Sept. 6	8556	t. 60	,,	7−2, 9+1	8·8
8	8558	,,	,,	=9	8·9
9	8559	t. 30	,,	7−2·5, =9	8·9
11	8561	,,	,,	7−2·5, =9	8·9
14	8564	,,	,,	7−3·5, 11+1, 10−1	9·0
18	8568	t. 60	,,	=16	9·5
Oct. 6	8586	t. 75	,,	34−3, 43+1·5	10·7
24	8604	T. 120	,,	43−6, 51−3	11·5
25	8605	T. 167	,,	55−1	11·5
Nov. 5	8616	T. 120	,,	69−2, 73+1	12·2
7	8618	,,	,,	69−2, 73+1	12·2
10	8621	,,	,,	69−2·5, 73+1	12·2
15	8626	T. 150	,,	69−2, 73+1	12·2
20	8631	,,	,,	69−2·5, 73+1	12·2
Dec. 8	8649	,,	,,	75−1	12·5
20	8661	T. 120	,,	64−1·5, 69+1	11·9
29	8670	t. 120	,,	51−1·5, 55+1	11·3
31	8672	,,	,,	51−1, 55+1	11·3
1910.					
Jan. 10	8682	t. 120	I	32−2, 40+1, 42+2, 43+2	10·6
19	8691	t. 75	,,	22−2·5, 34+2·5, 32+1·5	10·2
21	8693	T. 95	I	22−1·5, 34+4, 25−1, 29+1	10·0
25	8697	T. 50	,,	10−7, 24+2, 17−1·5, 21+1, 22+2	9·7
26	8698	,,	,,	10−7·5, 24+1·5, 17−1·5, 21+0·5, 22+2·5	9·7
30	8702	,,	,,	10−7, 24+2, =21, 22+1	9·8
Feb. 2	8705	,,	,,	10−7·5, 24+1·5, 21−0·5, 22+0·5	9·8
4	8707	,,	,,	10−7·5, 24+1·5, 17−1·5, 21+1	9·8
8	8711	,,	,,	10−7, 24+2, 17−1, 21+1, 22+2	9·7



LIGHT CURVE OF V CASSIOPEIÆ, 1909-10.—A. N. BROWN.

The Observations—continued.

Date.	Julian date.	Instr.	Class.	Comparisons.	Ded. mag.
1910.					
Feb. 11	8714	T. 50	1	10 − 6, 24 + 2·5, 15 − 0·5, 17 + 0·5	9·6
15	8718	,,	,,	7 − 5, 13 + 1·5, 10 − 6, 24 + 3	9·4
22	8725	,,	,,	7 − 2·5, 11 + 2·5, 8 − 1·5, 10 + 1	8·9
Mar. 5	8736	t. 30	,,	5 − 0·5, 6 + 2·5	8·4
13	8744	T. 50	,,	4 − 4·5, 5 + 1·5	8·2
14	8745	,,	,,	4 − 4·5, 5 + 1·5	8·2
15	8746	,,	,,	4 − 4, 5 + 1·5	8·1
22	8753	,,	,,	4 − 4, 5 + 1·5	8·1
26	8757	t. 30	2	4 − 4, 5 + 1·5	8·1
27	8758	T. 50	1	4 − 4·5, 5 + 1·5	8·2
29	8760	,,	,,	4 − 5, 5 + 1	8·2
Apr. 1	8763	,,	,,	4 − 5·5, 5 + 1	8·2
2	8764	,,	,,	4 − 5, 5 + 1	8·2
10	8772	t. 60	,,	5 − 2·5, 7 + 1, 6 + 1	8·5
15	8777	,,	,,	6 − 4·5, 12 + 1·5, 7 − 4·5, 13 + 2·5	9·1
May 6	8798	T. 50	,,	19 − 5, 34 + 1·5	10·2
9	8801	,,	,,	22 − 4, 34 + 1, 29 − 0·5	10·2
12	8804	T. 95	,,	34 − 2, 40 + 1	10·6
14	8806	T. 120	,,	34 − 2·5, 40 + 1, 42 + 1	10·7

The Comparison Stars used.

Hagen's number.	H.P. Magnitude.	Hagen's number.	H.P. Magnitude.	Hagen's number.	H.P. Magnitude.
3	6·3	15	9·5	40	10·7
4	7·7	16	9·5	42	10·8
5	8·3	17	9·6	43	10·9
6	8·6	19	9·7	51	11·2
7	8·6	21	9·8	55	11·4
8	8·8	22	9·9	64	11·8
9	8·9	24	9·9	69	12·0
10	9·0	25	10·0	73	12·3
11	9·1	29	10·1	75	12·4
12	9·2	32	10·3		
13	9·3	34	10·4		

Ludgrove, New Barnet, Herts:
1910 *May* 30.

Results of Micrometer Measures of Double Stars made with the 28-inch Refractor at the Royal Observatory, Greenwich, in the year 1909.

(*Communicated by the Astronomer Royal.*)

The measures were made with a bifilar position-micrometer on the 28-inch refractor, focal length 28 feet. The power generally employed was 670. When bright stars were observed a blue glass shade was usually employed to diminish the light and irradiation. The initials in the last column are those of the observers, viz.—

L.	Mr. Lewis.	W.B.	Mr. Bowyer.
B.	Mr. Bryant.	H.F.	Mr. Furner.

The stars have been observed from a working catalogue containing all double stars showing a relative motion, and selected pairs from the Hussey and Aitken catalogues.

Some of these being wide pairs of no immediate interest, the present list of measures is confined to stars of which the separation is under 4″, or which show orbital motion.

Stars observed but not included in this list :—

Σ 78	Σ 645	Σ 1300	Σ 1534	Σ 2272 Aa
122	648	1311	1634	Ab
180	734 AC	1327 AB	1651	Ac
183 AC	752	AC	1666	Ad
254	786	BC	1700	Ae
289	811	1384	1724	Af
295	915	1395	1812	Ag
326	1089	1419	1835	2475
346 AC	1158	1426 AC	1923	2524
450	1196 AC	1434	2109	2793 AC
458	BC	1446	2120	2824
479	1123	1447	2182	2895
546	1124	1487	3074	
			3076	
	OΣ 225			
β 45	β 340	β 883 AC	β 887 AC	β 931
139 AC	441	896 AC	AD	1310 AC

and 27 miscellaneous pairs.

Royal Observatory, Greenwich:
1910 *June* 6.

Micrometric Observations of Double Stars at the Royal Observatory, Greenwich.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1909.	Obs.
	h m	° ′	°	″					
Σ 3056 ...	0 0	56 14	146·0	0·52	1	7·4	7·4	·967	W.B.
OΣ 2 ...	0 9	63 31	32·7	0·62	1	6·9	8·3	·849	L.
β 779 ...	0 23	66 55	251·5	0·86	1	8·5	9·0	·919	H.F.
Holden 61	0 31	75 37	226·8	1·55	1	9·5	11·2	·919	H.F.
Hussey 410	0 32	68 28	317·5	3·20	1	9·0	11·0	·849	L.
Hussey 411	0 33	67 49	98·9	0·54	1	8·5	8·5	·849	L.
Hussey 413	0 42	67 14	250·8	0·90	1	8·0	9·2	·849	L.
β 495 ..	0 44	71 48	218·3	0·92	1	7·5	7·5	·849	L.
Σ 67 ...	0 47	79 53	1·8	1·68	1	8·3	9·0	·919	H.F.
Hussey 414	0 47	66 51	117·7	1·90	1	9·0	12·5	·849	L.
Σ 73 ...	0 50	66 52	31·2	0·69	2	6·2	6·8	·471	W.B.
Σ 82 ...	0 56	81 0	310·2	1·59	1	8·3	9·3	·919	H.F.
β 867 ...	0 56	78 33	172·0	0·96	1	8·1	8·6	·919	H.F.
Σ 113 ...	1 15	90 58	1·0	1·37	1	6·2	7·2	·997	H.F.
OΣ 31 ...	1 29	82 15	80·2	3·70	1	6·9	11·0	·919	H.F.
β 507 ...	1 31	63 42	157·8	1·97	2	7·8	10·6	·073	W.B.
β 5 ...	1 34	73 50	290·9	1·29	2	7·0	9·0	·073	W.B.
Σ 178 ...	1 47	79 38	198·6	2·91	2	7·8	7·8	·958	H.F.
β 260 ...	1 48	75 0	241·3	0·83	1	8·3	9·0	·066	L.
β 512 ...	1 49	71 9	21·4	1·60	1	9·0	13·0	·066	L.
Σ 183 AB	1 50	61 38	358·3	0·65	2	7·5	8·2	·064	W.B.
β 515 ...	1 56	73 52	261·6	1·32	1	7·7	12·5	·066	L.
Σ 227 ...	2 7	60 6	73·8	3·51	1	5·0	6·4	·104	L.
			71·7	3·40	1	...		·893	W.B.
Hussey 807	2 9	55 30	328·8	0·71	1	8·4	8·6	·066	L.
β 8 ...	2 17	81 32	204·5	0·99	3	8·3	9·2	·685	H.F.
Σ 285 ...	2 33	56 58	170·9	1·83	1	7·0	7·7	·104	L.
β 1315 ...	2 34	75 53	130·3	1·51	3	8·3	9·3	·375	W.B.
OΣ 43 .	2 35	63 46	38·5	1·27	2	7·2	8·8	·073	W.B.
Σ 299 ...	2 39	87 8	291·2	2·57	1	3·0	6·8	·919	H.F.
Σ 305 ...	2 42	71 0	316·1	3·03	3	7·3	8·2	·053	W.B.
Hussey 604	2 43	54 2	198·5	2·26	1	9·0	11·0	·142	W.B.
Σ 311 ...	2 44	72 54	118·6	2·91	1	4·9	8·4	·893	W.B.
β 1173 ...	2 53	66 14	347·1	0·19	1	7·7	7·8	·967	W.B.
β 525 ...	2 54	68 45	157·1	0·30	4	7·0	7·0	·314	W.B.
Σ 333 ...	2 54	69 1	202·7	1·33	2	5·7	6·0	·088	W.B.
Hussey 431	2 56	68 43	189·6	1·06	1	9·5	9·7	·919	H.F.
Σ 346 AB	3 0	65 6	94·9	0·42	3	6·0	6·0	·053	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Σ 346 AB ...	3 0	65 6	87·0	0·37	1	6·0	6·0	·066	L.
Σ 355 ...	3 3	81 57	147·9	2·50	1	8·7	9·5	·919	H.F.
β 1030 ...	3 5	68 36	152·3	0·49	3	8·4	8·4	·103	W.B.
OΣ 53 ...	3 12	51 41	218·7	0·59	2	7·2	8·0	·158	W.B.
Σ 380 ...	3 17	81 33	62·1	1·19	1	8·3	9·3	·919	H.F.
Hussey 1058	3 19	50 6	118·2	0·81	2	7·8	8·5	·158	W.B.
Σ 412 ...	3 29	65 50	151·8	0·22	1	6·6	6·7	·967	W.B.
Σ 413 ...	3 30	56 37	308·4	2·76	1	8·5	8·5	·104	L.
			307·3	2·46	2	...		·136	W.B.
β 533 ...	3 30	58 37	40·1	0·74	1	7·0	7·0	·066	L.
			48·1	0·52	1	...		·967	W.B.
Σ 425 ...	3 34	56 10	267·9	2·18	1	7·3	7·3	·066	L.
			269·8	2·44	2	...		·136	W.B.
Σ 438 ...	3 38	67 34	243·9	1·99	2	8·5	10·5	·115	W.B.
β 535 ...	3 39	58 0	56·2	0·81	1	4·0	8·5	·104	L.
Hough 504	3 39	54 26	188·7	1·22	1	7·8	8·0	·104	L.
			183·3	1·07	2	...		·136	W.B.
Σ 442 ...	3 40	67 33	270·2	2·47	2	9·0	9·5	·084	W.B.
Hussey 1066	3 42	69 30	265·8	1·19	1	9·0	10·3	·131	H.F.
Σ 453 ...	3 44	66 13	48·4	0·64	1	5·0	8·0	·142	W.B.
Hough 324	3 44	75 18	340·8	0·82	2	8·1	8·3	·085	H.F.
OΣ 65 ...	3 45	64 41	202·2	0·41	3	6·5	6·8	·103	W.B.
Hussey 815	3 51	68 30	204·0	2·49	1	8·0	12·0	·131	H.F.
Hussey 24	3 53	78 46	265·5	1·36	1	8·5	11·3	·131	H.F.
Hussey 25	3 53	78 8	326·9	0·87	1	8·6	9·1	·118	W.B.
Hussey 27	3 54	80 28	212·2	0·53	1	8·1	8·5	·131	H.F.
Hussey 28	3 55	78 48	347·8	0·93	2	9·0	9·2	·085	H.F.
Σ 483 ...	3 58	50 44	192·9	0·65	2	8·0	9·5	·158	W.B.
Σ 493 ...	4 2	84 33	91·8	1·48	1	8·5	9·0	·038	H.F.
β 1232 ...	4 3	61 3	347·0	0·49	1	8·4	9·3	·131	H.F.
			345·6	0·46	1	...		·173	W.B.
Hussey 301	4 4	79 28	204·4	0·94	1	8·5	9·6	·131	H.F.
Hough 326	4 4	61 35	160·8	0·42	3	8·0	8·0	·129	W.B.
Σ 499 ...	4 5	66 7	291·4	1·61	2	9·2	9·3	·107	W.B.
OΣ 74 ...	4 7	80 35	300·4	0·54	1	8·0	8·5	·131	H.F.
OΣ 77 ...	4 10	58 31	203·3	0·27	2	7·5	7·5	·158	W.B.
Σ 535 ...	4 18	78 50	323·1	1·68	2	6·7	8·2	·073	W.B.
			326·8	1·54	2	...		·085	H.F.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1909.	Obs.
	h m	° ′	°	″					
OΣ 82 ...	4 18	75 10	102·9	0·67	1	7·0	9·0	·104	H.F.
Hussey 303	4 19	68 40	193·2	2·45	1	8·5	12·0	·104	H.F.
Σ 562 ...	4 29	67 29	281·4	1·90	2	7·0	10·7	·117	W.B.
Σ 567 ...	4 31	70 41	323·8	1·64	2	8·5	9·0	·107	W.B.
Hussey 305	4 32	69 8	279·0	2·00	3	9·0	10·2	·118	W.B.
Σ 572 ...	4 33	63 14	198·4	3·78	3	6·5	6·5	·050	W.B.
Σ 577 ...	4 36	52 39	64·4	1·55	2	7·7	7·7	·138	W.B.
Hough 333	4 38	69 55	159·2	2·34	2	9·0	9·3	·059	W.B.
β 552 ...	4 47	76 30	231·0	0·48	1	7·0	10·0	·181	L.
Σ 620 ...	4 53	76 11	233·2	4·03	2	8·4	9·4	·107	W.B.
Σ 622 ...	4 53	88 28	169·0	2·29	1	8·2	8·2	·181	L.
β 1238 ...	4 56	63 36	11·0	1·46	1	8·1	11·3	·181	L.
Hough 224 AB	4 59	61 24	282·9	1·91	3	9·0	10·7	·117	W.B.
OΣ 95 ...	5 0	70 19	320·0	0·81	2	6·6	7·2	·064	W.B.
			325·3	0·84	1	...		·181	L.
Hussey 446	5 2	67 23	190·4	1·36	1	9·2	9·8	·181	L.
Σ 643 ...	5 3	81 42	299·9	2·79	2	8·5	8·5	·089	W.B.
OΣ 98 ...	5 3	81 37	159·4	0·98	1	6·0	6·8	·181	L.
Σ 644 ...	5 4	52 48	219·9	1·64	2	6·7	7·0	·136	W.B.
Σ 665 ...	5 10	70 22	256·3	1·76	2	8·3	9·2	·107	W.B.
Σ 670 ...	5 11	71 40	165·2	2·31	2	7·7	8·2	·088	W.B.
Σ 678 ...	5 13	85 25	100·8	3·30	1	8·3	8·8	·041	W.B.
β 887 AB ...	5 17	56 40	184·6	1·48	1	9·0	10·5	·181	L.
β 887 Ff ...	...		9·1	2·99	1	12·5	13·5	·181	L.
Σ 706 ...	5 21	59 43	39·7	3·65	2	8·2	9·3	·136	W.B.
Hough 226	5 21	62 28	59·2	0·60	2	7·0	7·0	·107	W.B.
Σ 719 ..	5 24	60 31	327·2	1·17	3	7·0	9·5	·119	W.B.
Σ 726 ...	5 26	79 48	260·9	1·31	2	8·0	8·5	·080	W.B.
β 1048 ...	5 28	91 40	0·3	1·67	1	6·2	10·7	·019	H.F.
Σ 734 AB	5 29	91 47	357·0	1·98	1	7·0	8·6	·131	H.F.
β 1049 CD	...		300·6	0·98	1	8·7	9·7	·131	H.F.
Σ 742 ...	5 31	68 4	260·9	3·48	3	7·2	7·8	·148	W.B.
Σ 749 ...	5 32	63 8	166·7	0·96	4	7·1	7·2	·122	W.B.
OΣ 112 ...	5 34	52 6	67·8	0·64	3	7·3	8·0	·132	W.B.
OΣ 115 ...	5 39	74 58	117·6	0·57	1	7·1	7·9	·096	W.B.
Σ 787 ...	5 41	68 43	73·6	1·25	2	8·1	8·5	·128	W.B.
			69·2	1·28	1	...		·131	H.F.
OΣ 118 ...	5·43	69 9	318·2	0·56	1	6·2	7·7	·142	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Lewis ...	5 43	60 20	164·4	3·05	1	8·8	9·8	·142	W.B.
OΣ 123 ...	5 49	79 46	179·7	2·34	2	7·0	8·7	·082	W.B.
OΣ 122 ...	5 50	53 4	145·5	0·30	1	7·3	8·0	·142	W.B.
Σ 821 ...	5 53	60 23	6·6	2·26	2	8·0	9·8	·136	W.B.
Barnard 4 AB	5 57	67 43	190·9	1·77	3	9·0	9·3	·085	W.B.
AG 107 ...	6 7	65 33	175·2	1·39	2	9·0	9·2	·080	W.B.
H 385 AB	6 14	67 52	47·4	1·78	1	8·7	9·4	·131	H.F.
OΣ 140 ...	6 21	74 26	115·1	2·80	2	7·0	9·5	·088	W.B.
AG 112 ...	6 22	65 25	28·8	2·81	2	9·0	9·1	·080	W.B.
β 896 AB	6 26	57 46	206·2	1·02	1	7·0	10·0	·257	L.
β 1021 ...	6 26	61 33	79·4	0·89	1	8·1	9·4	·257	L.
OΣ 149 ...	6 31	62 38	267·8	0·79	3	6·5	9·0	·225	W.B.
AG 119 ...	6 39	66 28	76·0	1·40	1	8·5	9·0	·271	W.B.
Σ 957 ...	6 39	59 5	93·0	3·68	2	7·5	9·0	·136	W.B.
Σ 981 ...	6 50	59 43	144·4	2·79	2	8·0	8·0	·136	W.B.
AG 134 AB	6 57	65 24	20·8	1·75	1	9·0	9·2	·271	W.B.
Σ 1014 ...	7 0	63 44	216·1	2·13	2	8·7	8·7	·140	W.B.
Σ 1037 ...	7 7	62 37	293·3	0·54	4	7·1	7·1	·201	W.B.
OΣ 520 ...	7 8	61 21	356·1	0·79	3	7·0	9·0	·220	W.B.
β 1023 ...	7 10	63 58	297·3	0·41	2	8·4	8·5	·262	W.B.
Hussey 706	7 20	69 53	232·6	0·72	3	9·5	9·5	·265	W.B.
OΣ 171 ...	7 21	58 12	132·3	1·18	4	7·1	9·9	·201	W.B.
AG 140 ...	7 21	67 44	175·5	2·40	3	8·7	10·3	·265	W.B.
Σ 1094 ...	7 22	74 30	95·1	2·41	2	7·7	8·7	·197	W.B.
Hussey 707	7 29	68 11	16·8	2·74	1	8·5	12·8	·257	L.
Hussey 457	7 35	66 33	152·8	2·41	1	8·5	12·3	·257	L.
Procyon ...	7 35	84 32	22·5	5·04	1	1	10	·298	W.B.
Hough 250	7 52	68 48	158·9	0·88	3	7·0	9·0	·268	W.B.
Σ 1171 ...	7 56	66 10	321·5	2·41	1	6·2	10·7	·257	L.
Σ 1187 ...	8 4	57 31	40·8	2·31	2	7·1	8·0	·262	W.B.
Σ 1196 AB	8 7	72 4	331·9	1·23	5	5·0	5·7	·273	W.B.
AG 154 ...	8 32	66 26	2·6	1·63	3	9·1	9·3	·259	W.B.
Küstner 32	8 36	70 24	168·4	2·08	2	8·7	10·2	·262	W.B.
Σ 1273 AB	8 42	83 14	196·2	0·28	1	4·0	5·5	·298	W.B.
Σ 1273 $\frac{AB}{2}$ & C	...		236·4	3·43	1	3·8	7·8	·298	W.B.
β 335 ...	8 44	87 3	273·3	2·39	1	7·2	10·5	·131	H.F.
AG 157 ...	8 45	66 32	76·0	1·93	2	9·3	9·5	·253	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1909.	Obs.
	h m	° ′	°	″					
β 211 ...	8 57	86 58	264·9	0·76	1	7·5	10·0	·131	H.F.
AG 162 ...	9 2	59 0	108·0	3·67	3	9·0	9·1	·265	W.B.
OΣ 197 ...	9 5	86 41	63·6	1·33	1	7·4	9·0	·131	H.F.
Aitken 127	9 16	69 55	28·6	1·51	2	9·3	10·0	·262	W.B.
AG 165 ...	9 18	67 27	193·5	1·26	2	9·1	9·3	·248	W.B.
OΣ 201 ...	9 19	61 43	222·0	1·40	2	7·5	9·0	·248	W.B.
β 105 ..	9 19	63 26	201·6	2·66	2	4·9	10·7	·248	W.B.
Σ 1372 ...	9 32	73 22	57·2	0·66	3	8·2	8·3	·261	W.B.
Σ 1397 ...	9 52	64 31	109·9	1·23	1	8·5	10·3	·249	W.B.
Weisse 23 ...	10 3	83 12	306·4	3·36	1	9·5	9·6	·131	H.F.
Σ 1413 ...	10 7	73 13	276·8	2·16	2	8·9	8·9	·255	W.B.
OΣ 213 ...	10 8	62 8	100·7	0·83	1	7·8	9·5	·131	H.F.
Σ 1417 ...	10 10	70 26	261·3	2·35	2	8·2	8·2	·280	H.F.
Lewis 10 ...	10 10	71 40	9·1	1·55	1	8·0	8·5	·252	H.F.
Hussey 634	10 11	56 24	164·8	1·76	2	8·4	9·1	·256	W.B.
OΣ 215 ...	10 11	71 49	204·3	0·86	2	7·0	7·2	·280	H.F.
Σ 1423 ...	10 14	68 59	57·1	1·48	2	8·6	9·3	·248	W.B.
Σ 1426 AB	10 16	83 7	284·6	0·91	3	7·5	8·0	·306	W.B.
OΣ 216 ...	10 18	74 11	109·7	1·15	3	7·0	10·5	·265	W.B.
Σ 1429 ...	10 20	64 55	248·6	0·81	4	8·3	8·3	·275	W.B.
OΣ 217 ...	10 22	72 19	148·0	0·87	3	7·3	7·8	·261	W.B.
OΣ 218 ...	10 23	85 59	81·8	0·93	1	7·3	9·2	·307	H.F.
Σ 1439 ...	10 25	68 44	110·1	1·75	2	8·0	8·5	·256	W.B.
Σ 1450 ...	10 30	80 53	162·3	2·24	1	6·0	8·7	·334	L.
			155·2	2·34	4	...		·355	W.B.
Σ 1457 ...	10 34	83 48	313·4	1·37	1	7·6	8·5	·334	L.
			316·1	1·56	2	...		·343	W.B.
Perrotin AB	10 35	70 17	239·9	0·92	2	7·5	9·7	·378	W.B.
Σ 1468 ...	10 40	68 49	333·2	3·93	2	8·7	8·7	·285	W.B.
OΣ 228 ...	10 42	66 57	187·2	0·53	2	7·2	8·1	·344	L.
β 915 ...	10 45	65 14	232·2	1·73	2	9·0	9·2	·344	L.
Hough 374	10 45	66 41	89·8	3·63	2	8·4	12·0	·344	L.
Hussey 567	10 48	67 23	187·0	0·80	2	9·3	10·0	·378	W.B.
Hussey 568	10 50	68 48	28·8	0·51	1	9·3	9·8	·375	W.B.
AG 173 ...	10 56	86 33	124·2	1·97	2	9·1	9·3	·287	W.B.
Σ 1500 ...	10 56	93 0	307·2	1·73	2	7·6	8·2	·287	W.B.
Σ 1504 ...	10 59	85 53	287·7	1·27	1	7·5	7·6	·345	H.F.
β 1282 ...	11 9	68 59	193·2	0·60	1	9·0	9·3	·353	L.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Σ 1517 ...	11 9	69 23	80·6	0·40	3	7·3	7·3	·311	W.B.
			85·8	0·37	1	...		·353	L.
OΣ 232 ...	11 10	51 56	233·5	0·51	2	7·0	7·8	·378	W.B.
Σ 1523 ...	11 13	57 27	125·7	2·76	3	4·0	4·9	·368	W.B.
Σ 1527 ...	11 14	75 14	18·3	3·15	3	6·9	8·1	·316	W.B.
β 791 ...	11 15	82 38	196·9	1·83	1	8·3	10·3	·345	H.F.
Σ 1536 ...	11 19	78 58	49·3	2·21	2	3·9	7·1	·253	W.B.
Σ 1537 ...	11 20	68 53	354·8	2·41	2	7·6	9·6	·253	W.B.
Lewis 11, Lalande 21846	11 25	59 4	4·7	0·76	1	7·0	11·0	·334	L.
Σ 3072 ...	11 26	96 13	330·4	3·66	1	7·4	10·4	·345	H.F.
AG 175 ...	11 30	88 0	183·3	1·97	1	8·6	8·9	·345	H.F.
Σ 1554 ...	11 31	76 39	77·2	1·04	1	8·8	8·8	·348	W.B.
			82·0	0·77	1	...		·353	L.
Σ 1555 ...	11 32	61 43	358·2	0·26	1	6·4	6·8	·353	L.
Aitken 678	11 35	64 12	155·6	1·33	2	7·6	11·3	·308	W.B.
Hussey 888	11 38	68 25	144·5	0·64	2	8·4	8·9	·293	W.B.
β 917 ...	11 39	78 48	177·7	3·66	1	8·0	10·4	·345	H.F.
β 603 ...	11 44	75 13	309·2	1·01	1	6·4	10·2	·348	W.B.
			313·3	0·80	1	...		·353	L.
Hussey 890	11 57	78 10	243·2	1·95	1	9·0	10·0	·353	L.
Hough 535	11 58	67 44	143·3	2·84	1	8·0	12·0	·334	L.
Hussey 570	12 9	68 12	109·6	2·32	1	8·8	13·0	·334	L.
Σ 1620 ...	12 11	80 28	78·1	2·10	3	8·5	10·0	·290	W.B.
Σ 1621 ...	12 11	83 51	135·3	2·11	2	8·8	10·3	·293	W.B.
Hussey 1138	12 13	77 43	1·5	1·44	2	9·5	9·9	·318	W.B.
Hussey 737	12 17	85 57	50·0	2·40	1	9·0	9·3	·345	H.F.
Σ 1639 ...	12 20	63 55	348·4	0·49	1	6·7	7·9	·334	L.
			344·2	0·42	3	...		·391	W.B.
Σ 1643 ...	12 23	62 28	35·3	2·11	2	8·7	9·2	·287	W.B.
Σ 1647 ...	12 26	79 47	222·9	1·44	3	7·5	7·8	·290	W.B.
Σ 1658 ...	12 31	82 3	359·5	2·35	2	8·5	10·0	·293	W.B.
Σ 1661 ...	12 31	78 6	241·4	2·31	2	8·5	8·5	·375	H.F.
Σ 1668 ...	12 36	80 41	194·3	1·68	3	7·5	8·0	·290	W.B.
β 924 ...	12 37	82 42	29·0	3·90	1	5·8	11·6	·345	H.F.
Hussey 892	12 38	74 59	157·6	1·07	2	9·3	9·3	·318	W.B.
Σ 1674 ...	12 39	81 57	171·4	2·18	2	8·5	9·2	·388	W.B.
Hussey 893	12 43	77 13	34·5	1·45	3	9·1	9·1	·352	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
β 459 ...	12 44	86 3	292·1	4·05	1	8·2	11·5	·345	H.F.
Σ 1680 ...	12 45	67 44	337·4	2·85	1	8·0	11·0	·345	H.F.
Holden 117	12 45	81 52	196·2	2·20	2	9·1	9·5	·338	W.B.
Hussey 894	12 49	76 20	140·0	1·02	3	9·1	9·1	·339	W.B.
Σ 1696 ...	12 53	59 9	203·3	3·58	2	8·0	8·2	·369	W.B.
Σ 1699 ...	12 54	62 2	2·8	1·55	2	7·8	7·8	·343	W.B.
β 112 ...	12 56	71 9	292·6	2·07	1	9·6	10·0	·345	H.F.
AGC 5 ...	12 56	92 53	154·6	1·14	1	6·0	11·0	·405	H.F.
Barnard 6...	12 58	73 58	44·1	2·76	2	9·1	9·1	·369	W.B.
Σ 1709 ...	12 58	66 1	250·9	2·47	3	7·4	9·7	·362	W.B.
Σ 1710 ...	12 58	79 5	261·6	2·67	1	8·7	10·0	·345	H.F.
Σ 1711 ...	12 58	76 3	343·0	0·95	3	8·5	9·0	·389	W.B.
β 928 ...	12 59	95 57	308·3	2·12	1	7·9	8·9	·405	H.F.
β 929 ...	12 59	93 11	214·0	0·72	1	6·0	6·3	·405	H.F.
Σ 1716 ...	13 0	80 52	144·3	2·50	1	8·1	10·9	·405	H.F.
Hussey 1143	13 2	77 35	98·8	1·03	1	8·9	9·6	·288	W.B.
β 609 ...	13 6	94 28	1·2	0·82	1	7·0	11·0	·405	H.F.
Σ 1728 ...	13 6	72 0	12·4	0·42	3	6·0	6·0	·358	W.B.
β 800 ...	13 12	72 30	112·8	3·20	1	7·1	10·2	·356	W.B.
AG 186 ...	13 12	87 21	307·2	3·28	1	9·0	10·1	·405	H.F.
Σ 1734 ...	13 16	86 35	190·1	1·00	1	7·2	7·9	·405	H.F.
β 237 ...	13 22	75 9	203·4	3·45	1	8·3	10·3	·356	W.B.
AG 187 ...	13 23	69 4	117·3	1·61	2	9·5	9·5	·335	W.B.
OΣ 266 ...	13 24	73 49	342·2	1·70	2	7·3	7·8	·318	W.B.
β 113 ...	13 25	78 3	212·6	1·31	1	8·5	11·0	·405	H.F.
Küstner 45	13 30	74 16	294·5	0·99	1	9·8	10·0	·405	H.F.
Hussey 645	13 35	68 5	11·2	0·90	1	9·5	9·5	·381	W.B.
β 115 ...	13 41	80 29	223·5	1·46	1	8·0	11·5	·405	H.F.
β 801 ...	13 42	78 43	325·6	2·78	1	8·1	10·9	·405	H.F.
Küstner 47	13 50	57 25	119·2	2·01	1	9·5	10·2	·381	W.B.
OΣ 273 ...	13 52	84 16	106·6	0·97	1	7·5	8·0	·288	W.B.
β 937 ...	13 53	55 8	112·8	0·90	1	8·1	8·3	·381	W.B.
Σ 1792 ...	13 53	77 7	290·2	2·04	1	8·9	10·1	·288	W.B.
Aitken 687	13 56	61 8	307·0	0·99	1	9·2	9·3	·410	W.B.
Aitken 569	13 57	64 3	103·7	0·61	1	9 0	9·3	·381	W.B.
OΣ 277 AB	14 8	60 52	360·0	0·40	2	7·8	8·0	·477	W.B.
OΣ 279 ...	14 9	77 35	254·8	2·17	2	6·8	9·0	·366	W.B.
β 224 ...	14 9	77 1	52·2	0·54	1	8·9	9·3	·405	H.F.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Hough 541	14 16	77 25	92·5	2·41	1	9·3	10·2	·405	H.F.
Σ 1834 ...	14 17	41 5	106·6	0·12	3	7·1	7·2	·682	B.
β 1111 BC	14 19	81 8	56·9	0·15	1	8·4	8·4	·430	L.
Aitken 1104	14 19	82 6	273·8	0·92	1	9·0	9·0	·430	L.
Hough 542	14 23	68 59	258·6	0·67	1	8·8	8·8	·375	W.B.
Σ 3087 ...	14 32	70 12	44·0	1·82	2	9·5	9·5	·445	W.B.
Aitken 1107	14 36	84 33	77·6	0·35	1	8·0	9·2	·430	L.
Σ 1865 ...	14 37	75 53	137·9	0·57	1	3·5	3·9	·430	L.
			141·8	0·43	3	...		·499	B.
			140·2	0·37	2	...		·506	W.B.
Σ 1866 ...	14 37	80 6	202·0	0·92	1	8·2	8·2	·430	L.
Aitken 1109	14 38	83 2	35·0	0·80	1	7·3	9·8	·430	L.
Hussey 575	14 38	70 7	147·3	0·48	2	9·0	9·5	·436	W.B.
Σ 1879 ...	14 42	79 58	122·4	0·56	1	7·7	8·5	·430	L.
			119·1	0·54	3	...		·499	B.
Σ 1883 ..	14 44	83 41	237·0	0·35	2	7·0	7·0	·548	B.
Σ 1884 ...	14 44	65 17	51·0	1·62	1	6·2	7·8	·430	L.
Σ 1937 ...	15 19	59 24	34·1	0·92	1	5·5	6·0	·548	W.B.
Σ 1957 ...	15 32	76 47	150·3	1·18	2	7·9	9·6	·445	W.B.
Hussey 580	15 38	70 3	96·5	0·18	3	5·0	5·0	·563	B.
OΣ 303 ...	15 57	76 28	144·0	0·85	3	7·4	7·9	·451	W.B.
Σ 1998 ...	15 59	101 8	319·5	0·35	2	4·9	5·2	·512	B.
β 812 ...	16 3	72 52	117·5	0·85	3	8·2	8·3	·451	W.B.
			121·1	0·69	2	...		·596	B.
OΣ 309 ...	16 16	48 7	249·7	0·40	2	7·5	7·7	·596	B.
Hussey 481	16 17	66 48	224·1	0·50	2	7·3	9·2	·429	W.B.
Σ 2055 ...	16 26	87 49	68·4	0·94	1	4·0	6·1	·498	H.F.
Σ 3105 ...	16 27	96 50	32·5	0·31	2	7·7	7·7	·596	B.
Hussey 1173	16 27	55 55	76·4	0·20	2	8·4	8·7	·596	B.
OΣ 313 ...	16 30	49 42	145·7	1·03	2	7·2	7·8	·596	B.
Hussey 487	16 38	67 59	30·4	0·42	2	9·0	9·0	·596	B.
Σ 2084 ...	16 38	58 15	151·6	1·12	2	3·0	6·5	·623	W.B.
Σ 2094 ...	16 40	66 19	79·0	1·43	2	7·3	7·6	·445	W.B.
β 43 ...	16 44	87 6	248·5	0·98	1	8·7	8·8	·498	H.F.
Küstner 55	16 44	75 1	48·2	2·17	1	9·5	10·1	·471	H.F.
Σ 2106 ...	16 47	80 26	280·3	0·21	2	6·7	8·4	·596	B.
Σ 2107 ...	16 48	61 11	8·8	0·44	2	6·5	8·0	·596	B.
Aitken 350	16 50	60 45	138·3	0·31	2	9·0	9·0	·596	B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
AG 207 ...	16 51	65 20	212·5	3·23	1	9·0	11·5	·471	H.F.
OΣ 318 ...	16 53	75 43	252·1	2·70	1	6·7	9·3	·471	H.F.
OΣ 319 ...	16 54	74 43	65·1	0·94	3	7·5	8·5	·503	W.B.
OΣ 321 ...	16 55	75 34	7·1	0·79	1	7·7	8·7	·471	H.F.
Hough 555	17 1	56 39	181·3	0·81	1	9·3	9·3	·608	L.
Aitken 228	17 3	63 22	184·5	0·63	3	9·0	9·2	·555	W.B.
			182·5	0·64	1	...		·608	L.
Hussey 1176	17 5	53 57	119·6	0·17	2	6·0	6·0	·596	B.
		May be elongated at 117° Distance less than 0″·10						·608	L.
Hussey 1178	17 9	50 38	7·5	0·47	1	8·4	8·7	·608	L.
Hussey 489	17 12	69 47	46·7	0·96	3	9·2	10·5	·574	W.B.
H.C. Wilson 15	17 13	63 19	43·8	0·46	3	8·3	9·3	·540	W.B.
β 628 ...	17 15	57 15	346·1	0·42	1	9·0	9·5	·608	L.
β 630 ...	17 16	57 34	222·5	1·44	1	8·7	10·7	·608	L.
Lewis 15	17 16	57 25	294·3	2·65	1	10·0	11·0	·608	L.
Aitken 232	17 18	64 12	102·9	0·52	3	8·7	9·4	·555	W.B.
β 1284 ...	17 19	75 1	179·4	1·05	1	8·3	11·3	·471	H.F.
Hussey 1179	17 21	51 21	282·2	0·23	2	7·0	7·1	·596	B.
			269·0	0·37	1	...		·608	L.
Σ 2173 ...	17 26	91 0	279·4	0·27	2	6·0	6·3	·580	B.
Hussey 179	17 27	78 43	51·2	2·01	2	8·8	8·9	·534	H.F.
OΣ 331 ...	17 28	87 6	342·1	0·96	2	7·5	9·0	·534	H.F.
β 962 ..	17 34	28 4	349·7	0·95	2	5·0	11·0	·337	W.B.
			355·0	1·06	1	...		·353	L.
β 631 ...	17 35	90 36	53·3	0·35	2	7·0	7·0	·532	B.
AG 211 ...	17 37	69 40	128·5	2·63	2	9·0	9·5	·534	H.F.
Σ 2199 ...	17 37	34 12	84·8	1·72	1	7·2	7·8	·375	W.B.
AG 212 ...	17 38	84 38	23·7	2·92	1	9·5	9·5	·597	H.F.
Σ 2203 ...	17 38	48 18	316·0	0·64	2	7·5	7·8	·596	B.
Σ 2200 ...	17 39	84 7	166·9	1·82	1	8·0	8·8	·597	H.F.
Hough 560	17 40	56 1	94·6	0·52	2	8·0	8·0	·596	B.
			93·4	0·49	1	...		·654	W.B.
Σ 2205 ...	17 42	72 15	307·7	2·10	1	8·3	8·7	·597	H.F.
OΣ 337 ...	17 46	82 45	265·8	0·34	2	7·5	8·0	·532	B.
OΣ 338 ...	17 48	74 40	13·7	0·78	2	6·6	6·9	·532	B.
Aitken 234	17 49	64 23	30·3	0·41	2	8·8	9·1	·580	B.
AC 8 ...	17 49	60 19	251·8	0·26	2	8·2	8·2	·580	B.
Hough 71 ...	17 49	34 36	229·7	3·39	1	9·2	9·6	·375	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Aitken 235	17 50	65 0	262·8	0·29	2	7·9	8·1	·580	B.
AC 9 ...	17 51	60 10	235·0	1·02	2	8·3	8·8	·623	W.B.
OΣ 339 ...	17 52	68 29	175·3	2·98	2	7·5	9·9	·623	W.B.
Σ 2275 ...	18 0	50 39	131·4	0·67	2	9·0	9·2	·596	B.
Secchi ...	18 1	50 33	324·8	0·83	1	9·0	9·2	·608	L.
* ...	18 1	50 33	216·5	1·05	1	10·0	11·0	·608	L.
Hough 565	18 0	63 56	72·6	0·41	2	8·3	8·3	·596	B.
* ...	18 1	87 23	332·0	3·60	1	9·5	10·5	·564	L.
Σ 2272 AB	18 1	87 27	154·6	3·10	12	4·5	6·0	·572	W.B.
			158·9	3·34	1	...		·564	L.
OΣ 341 ...	18 2	68 34	93·8	0·43	1	6·4	7·7	·564	L.
Σ 2281 ...	18 5	86 2	292·6	0·28	4	5·7	7·2	·603	W.B.
Σ 2283 ...	18 5	83 52	83·2	0·84	2	7·2	7·7	·541	B.
Hussey 314	18 5	71 23	144·5	0·43	1	8·3	8·5	·635	W.B.
Σ 2289 ...	18 6	73 33	229·7	1·04	2	6·0	7·1	·555	W.B.
Hussey 674	18 7	39 37	279·9	0·49	1	7·5	8·0	·375	W.B.
Hussey 317	18 7	72 48	17·7	1·63	2	8·5	8·8	·555	W.B.
Aitken 238	18 8	64 42	94·2	0·54	2	8·5	9·5	·661	W.B.
Σ 2292 ...	18 9	62 23	86 9	1·13	2	8·0	8·1	·553	W.B.
AG 218 ...	18 15	86 42	277·7	2·68	2	9·0	9·3	·571	H.F.
AG 219 ...	18 15	87 55	31·3	2·88	2	9·1	10·2	·571	H.F.
Perrine ...	18 16	75 59	3·0	3·74	1	8·8	10·2	·545	H.F.
β 640 ...	18 17	62 31	329·3	1·99	1	7·5	12·2	·564	L.
β 641 ...	18 18	68 32	341·3	0·95	2	7·1	9·0	·571	H.F.
Hussey 238	18 18	80 5	164·9	0·90	1	8·6	9·2	·597	H.F.
Hough 430	18 18	69 32	192·3	2·22	2	8·5	9·0	·649	W.B.
Hussey 581	18 19	75 4	121·0	0·46	1	8·4	9·0	·597	H.F.
Hough 83 ...	18 20	62 31	86·0	0·48	2	8·7	8·7	·652	W.B.
OΣ 350 ...	18 23	83 38	166·4	1·97	1	7·4	9·0	·545	H.F.
Hussey 583	18 26	76 16	307·2	0·77	1	8·6	9·1	·597	H.F.
OΣ 354 ...	18 28	83 17	171·8	0·72	1	7·2	8·0	·597	H.F.
Hussey 245	18 29	78 17	53·0	2·13	1	8·2	9·2	·635	W.B.
OΣ 358 ...	18 32	73 6	10·3	1·90	2	6·8	7·2	·532	W.B.
			7·4	1·92	1	...		·545	H.F.
Σ 2356 ...	18 35	61 23	55·5	0·99	2	8·0	9·0	·649	W.B.
Σ 2415 ...	18 51	69 30	294·8	2·01	3	6·6	8·5	·666	W.B.
Σ 2422 ...	18 53	64 2	93·2	0·76	2	7·6	7·7	·570	W.B.
Hussey 330	18 55	70 32	32·3	0·74	2	9·0	9·3	·570	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910.	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1909.	Obs.
	h m	° ′	°	″					
Hussey 331	18 55	71 58	188·6	0·77	2	8·4	12·4	·570	W.B.
Hussey 332	18 55	67 38	196·7	0·39	3	8·8	9·0	·578	W.B.
Hough 95	19 2	62 51	220·1	0·33	3	8·0	8·2	·621	W.B.
Hough 98	19 5	63 3	133·4	0·22	2	8·0	8·0	·605	W.B.
Hough 99	19 5	59 37	135·5	0·42	2	9·0	9·0	·624	W.B.
Aitken 150	19 6	69 39	100·6	0·46	2	8·9	9·0	·605	W.B.
Hussey 334	19 8	72 0	245·6	1·12	1	8·5	11·0	·728	H.F.
β 1204 ...	19 8	87 32	12·3	0·49	1	7·7	8·5	·728	H.F.
Aitken 151	19 8	68 53	125·5	0·47	3	7·6	8·9	·621	W.B.
Aitken 153	19 9	68 15	283·4	0·94	1	8·0	11·2	·594	W.B.
β 139 AB ...	19 9	73 18	138·7	0·68	1	6·7	8·0	·728	H.F.
Hussey 335	19 10	69 57	214·5	0·34	1	7·3	11·0	·594	W.B.
OΣ 371 ...	19 12	62 42	152·9	0·82	2	6·8	6·9	·660	W.B.
Σ 2491 ...	19 13	61 53	221·1	1·08	2	7·9	9·2	·659	W.B.
β 1256 ...	19 14	83 50	35·7	0·68	1	8·3	8·3	·728	H.F.
Hussey 339	19 21	71 32	45·8	0·43	3	8·6	8·6	·578	W.B.
Σ 2525 ...	19 23	62 52	308·6	0·66	3	7·5	7·7	·578	W.B.
			311·8	0·72	1	...		·832	L.
Hussey 340	19 24	71 42	125·1	1·00	1	9·0	9·3	·679	L.
Σ 2536 ...	19 28	72 24	76·6	1·70	1	8·0	11·0	·679	L.
Aitken 164	19 34	67 23	218·8	0·59	1	7·5	9·0	·679	L.
*	19 36	66 16	268·7	3·73	1	10·0	10·5	·679	L.
Hough 110	19 35	71 31	78·7	2·46	2	9·3	9·3	·647	W.B.
OΣ 380 ...	19 38	78 23	75·4	0·39	2	6·0	7·2	·647	W.B.
β 978 ...	19 48	66 43	234·3	0·93	1	8·3	8·4	·843	H.F.
β 979 ...	19 48	66 57	329·4	2·03	1	8·3	11·1	·843	H.F.
β 425 ...	19 54	69 57	60·0	1·37	4	8·8	9·0	·578	W.B.
AC 16 ...	19 54	62 59	58·4	0·35	3	7·5	8·0	·578	W.B.
AG 244 ...	19 54	68 6	277·5	1·16	1	9·0	10·4	·843	H.F.
β 1133 ...	19 56	58 25	336·0	0·98	1	6·8	9·5	·843	H.F.
β 439 ...	19 57	60 25	238·5	3·24	1	7·9	12·7	·843	H.F.
β 1258 ...	19 57	60 20	155·1	1·54	1	8·0	12·0	·843	H.F.
Aitken 380	20 0	57 55	205·0	1·26	1	9·3	9·4	·843	H.F.
Aitken 1197	20 2	60 29	337·4	0·33	2	9·0	9·5	·605	W.B.
β 428 ...	20 2	77 19	350·7	0·63	2	7·2	8·5	·570	W.B.
β 430 ...	20 8	54 27	29·0	1·01	1	9·3	10·2	·843	H.F.
Doolittle 14	20 8	64 23	260·2	1·68	1	9·2	10·0	·843	H.F.
β 982 ...	20 8	63 54	54·1	0·94	2	8·8	10·0	·570	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Aitken 1201	20 9	61 8	169·6	0·26	1	9·0	9·1	·594	W.B.
Aitken 1202	20 9	79 29	117·0	0·65	2	8·9	9·5	·570	W.B.
β 984 ...	20 14	63 55	215·7	0·81	2	7·9	8·2	·659	W.B.
Aitken 391	20 15	65 36	287·1	1·17	1	9·0	10·7	·660	L.
β 431 ...	20 17	54 1	217·5	0·57	1	8·5	8·8	·654	W.B.
β 1259 ...	20 18	59 41	165·6	0·38	2	8·3	8·7	·624	W.B.
Σ 2672 ...	20 18	66 31	293·6	0·79	2	8·7	8·8	·586	W.B.
Aitken 393	20 23	62 14	213·0	0·41	1	8·7	9·2	·654	W.B.
Σ 2695 ...	20 28	64 30	79·5	1·16	2	6·8	8·0	·730	W.B.
OΣ 408 ...	20 31	55 38	190·9	1·48	1	7·2	10·2	·881	H.F.
AG 258 ...	20 32	79 52	10·5	3·86	2	9·2	9·4	·614	W.B.
β 151 ...	20 33	75 43	176·8	0·20	3	4·5	6·0	·740	B.
Aitken 742	20 34	60 36	134·7	1·04	1	9·5	10·0	·881	H.F.
Aitken 743	20 34	60 21	306·2	0 96	1	9·0	12·0	·881	H.F.
Aitken 744	20 34	60 26	273·5	0·56	1	8·8	8·8	·654	W.B.
β 435 ...	20 35	75 19	113·5	2·79	1	8·6	10·9	·556	W.B.
OΣ 410 ...	20 36	49 45	10·5	0·63	1	6·4	6·7	·857	B.
Σ 2716 ...	20 37	58 1	53·0	2·79	1	6·0	8·2	·881	H.F.
Hough 137	20 37	60 31	278·5	0·83	1	6·5	10·8	·881	H.F.
β 267 ...	20 37	94 43	240·7	1·73	1	9·0	9·0	·677	H.F.
Hough 138CD	20 40	64 44	158·8	2·81	1	10·9	11·4	·813	L.
β 64 ...	20 41	77 37	177·4	0·74	1	8·7	9·0	·813	L.
Σ 2723 ...	20 41	78 1	109·8	1·13	1	7·3	8·0	·813	L.
AG 264 ...	20 42	65 38	175·8	1·88	2	9·0	9·1	·695	W.B.
β 364 ...	20 43	64 55	226·9	1·26	2	8·7	8·9	·695	W.B.
β 65 ...	20 43	84 19	187·3	0·94	1	5·2	8·8	·677	H.F.
OΣ 413 ...	20 44	53 50	51·6	0·57	1	5·0	6·3	·857	B.
β 66 ...	20 44	62 52	155·9	1·41	1	8·6	9·1	·663	W.B.
Σ 2729 ...	20 47	95 57	326·5	0·19	1	5·9	7·2	·761	B.
β 67 ...	20 47	59 25	294·8	1·34	1	6·9	10·2	·881	H.F.
Aitken 613	20 47	84 35	8·4	0·73	1	8·7	8·8	·827	H.F.
Aitken 1212	20 48	80 6	24·8	0·56	1	8·6	9·1	·827	H.F.
Hough 144	20 48	70 12	164·7	0·26	1	7·0	7·0	·761	B.
OΣ 417 ...	20 49	61 11	32·6	0·56	1	7·5	8·1	·654	W.B.
			32·3	0·64	1	...		·849	L.
Lewis ...	20 49	61 0	155·1	3·42	1	9·5	10·5	·849	L.
β 367 ...	20 51	62 15	160·1	0·22	1	7·5	7·9	·849	L.
OΣ 419 ...	20 51	53 16	213·7	1·70	1	7·2	10·5	·881	H.F.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910. h m	N.P.D. 1910. ° ′	Position Angle. °	Distance. ″	No. of Nights.	Mags.		Epoch 1909.	Obs.
Σ 2737 ...	20 55	86 3	276·7	0·37	1	5·7	6·2	·761	B.
OΣ 424 ...	20 55	74 47	326·8	0·60	1	7·5	8·7	·827	H.F.
β 69 ..	20 59	68 40	313·0	0·92	2	8·2	9·0	·620	W.B.
Σ 2749 AB	21 0	86 50	160·5	2·32	1	7·7	8·9	·827	H.F.
Secchi 3 BC	...		162·4	0·85	1	8·9	8·9	·827	H.F.
OΣ 430 ...	21 8	66 13	208·3	1·35	3	7·8	9·8	·594	W.B.
OΣ 535 ...	21 10	80 22	18·3	0·25	3	4·5	5·0	·740	B.
			24·0	0·24	3	...		·778	W.B.
			27·0 elongated			...		·679	L.
			20·5	0·18	1	...		·813	L.
Hussey 767	21 10	74 24	93·2	0·19	3	7·0	7·0	·740	B.
β 1261 ...	21 12	74 17	144·0	1·52	4	8·5	9·7	·615	W.B.
			148·5	1·51	1	...		·813	L.
Hough 286	21 16	52 8	8·9	0·14	1	6·0	6·0	·857	B.
Aitken 617	21 17	80 2	270·1	0·19	2	7·0	7·0	·682	B.
Aitken 295	21 17	62 39	222·2	0·42	1	8·5	8·7	·797	W.B.
β 164 AB ...	21 21	81 0	239·5	0·61	1	8·0	8·5	·677	H.F.
Σ 2799 ...	21 24	79 18	294·1	1·49	2	6·6	6·6	·637	W.B.
Hussey 371	21 31	65 57	154·5	0·19	1	7·0	7·5	·761	B.
β 1212 ...	21 35	90 28	274·1	0·40	2	6·5	6·9	·682	B.
OΣ 448 ...	21 37	61 4	235·3	0·66	1	7·7	8·7	·611	W.B.
Σ 2822 AB	21 40	61 40	126·2	2·07	1	4·0	5·0	·884	W.B.
Hough 166	21 40	62 34	75·2	0·27	1	7·5	7·5	·967	W.B.
β 989 AB ...	21 41	64 46	323·8	0·17	1	4·3	5·0	·591	W.B.
			330±	...	...	...		·726	W.B.
			315±	...	...	...		·846	W.B.
			333·1	0·10	1	...		·898	W.B.
			305·3	0·15	3	...		·740	B.
AG 276 ...	21 41	68 29	357·3	1·88	3	8·8	9·2	·698	W.B.
AG 277 ...	21 42	69 14	235·7	2·34	2	9·0	9·0	·641	W.B.
OΣ 452 ...	21 51	83 11	177·4	1·04	3	7·7	8·8	·744	W.B.
β 75 ...	21 51	79 33	46·1	0·88	3	8·1	8·5	·744	W.B.
OΣ 453 ...	21 52	83 12	265·3	0·60	2	7·5	8·0	·704	W.B.
Battermann	21 52	74 50	162·2	1·57	1	9·2	9·3	·679	L.
Σ 2849 ...	21 53	70 11	261·9	1·80	1	8·2	10·7	·679	L.
			260·2	1·45	2	...		·788	W.B.
Σ 2881 ...	22 10	60 52	98·1	1·45	1	7·7	8·2	·778	W.B.

Micrometric Observations of Double Stars—continued.

Star's Name.	R.A. 1910	N.P.D. 1910.	Position Angle.	Distance.	No. of Nights.	Mags.		Epoch 1909.	Obs.
	h m	° ′	°	″					
AG 281 ...	22 11	68 30	21·2	2″66	1	8·8	9·8	·679	L.
			21·4	2·42	2	...		·829	W.B.
Hussey 287	22 13	82 10	56·2	1·96	1	8·2	13·5	·679	L.
β 1218 ...	22 24	60 46	54·8	1·43	1	8·6	8·8	·967	W.B.
Hough475AB	22 29	64 3	316·6	0·79	2	8·5	8·7	·829	W.B.
Hough 296	22 36	75 56	53·2	0·29	1	5·8	5·9	·726	W.B.
Σ 2934 ...	22 38	69 3	131·4	0·70	3	8·2	9·2	·805	W.B.
Hough 482	22 47	64 5	50·4	0·23	1	7·2	7·2	·967	W.B.

Southern Double Star Measures. 4¼-in. Cooke Refractor.

By Geo. D. Hirst.

The following measures are in continuation of those given on pp. 474, 475.

Name.	Epoch.	R.A.	South Dec.	Mag.	Angle.	Dist.	Remarks.
		h m s	° ′		°	″	
Lac. 8550	1909.8	20 43 18	62 48	6·6 6·6	90·0	2·6	
Lac. 8912	1909.8	21 41 45	47 45	5·8 8·6	357·8	46·25	
Lac. 9455	1909.8	23 18 15	54 21	6·7 7·5	211·0	25·3	
θ Phœnicis	1909.8	23 34 6	47 11	6·6 7·6	271·2	4·1	
64 Toucani	1909.8	0 40 10	63 3	6·6 8·5	71·2	2·35	
p Eridani	1909.8	1 35 59	56 42	6·0 6·1	217·7	7·5	
Lac. 297	1909.9	0 59 15	60 37	7·4 7·7	128·6	4·26	
Dunlop 15	1909.9	3 36 11	40 41	7·2 7·9	329·1	7·13	
Lac. 584	1909.9	1 52 6	60 48	7·0 7·4	54·2	2·82	
Lac. 1100	1909.9	3 21 14	46 1	7·0 8·7	341·7	2·58	*

* Small star 9. m. bluish appears to be closing.

Sydney: 1910 *May* 25.

Errata.

The Secretaries are indebted to several correspondents for pointing out errata in the facsimile of work produced by General Babbage's calculating machine (*M.N.*, vol. lxx. p. 520).

These errors are not entirely the same as certain errors in the facsimile sheet distributed by General Babbage at the meeting.

General Babbage has kindly given the following explanation of this.

Two separate calculations A and B were made on the machine while it stood in the maker's shops, and several mistakes occurred.

1. A wrong value of π was given to the machine in both cases, so that the whole of the multiples are wrong as multiples of π.

2. In A the printing mechanism of the machine made errors in 8π, 9π, and 11π. This is the specimen reproduced in the *M.N.*

3. In B the printing mechanism made an error in 22π. This is the specimen distributed by General Babbage at the meeting.

The failure in printing was due to weakness in certain springs, which had been strengthened before the machine was exhibited; thus the printed figures did not agree with the calculated.

The following corrections should be made in the facsimile printed in the *M.N.*

In π: *Read* 3·14159265358979**3**, and carry corresponding correction throughout.

In 8π: *Read* 2513**2**.

,, 9π: ,, 2827**4**.

,, 11π: ,, 3455751**9**.